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Emergency Vector Control after Natural Disaster
Scientific Publication No. 419

Published by:

Pan American Health Organization
World Health Organization
525 Twenty-third Street, N.W.
Washington, DC 20037 USA

Available from:

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World Health Organization
525 Twenty-third Street, N.W.
Washington, DC 20037 USA

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HEALTH FOR ALL BY THE YEAR 2000

In 1977, the World Health Assembly decided that the main social target of the governments and of WHO should be the attainment by all people of the world by the year 2000 of a level of health that would permit them to lead a socially and economically productive life, that is, the goal popularly known as "health for all by the year 2000."

In 1978 the International Conference on Primary Health Care (Alma-Ata, USSR) declared that, as a central function of the national health system and an integral part of economic and social development, primary health care was the key to achieving that goal. Subsequently, the governments committed themselves—at the global level at the World Health Assembly, and at the regional level at meetings of the PAHO Governing Bodies—to implement the resolutions adopted for attaining health for all. In the Americas the high point of these mandates was reached on 28 September 1981 when the Directing Council of PAHO approved the Plan of Action for implementing the regional strategies for health for all by the year 2000. These strategies had been approved by the Directing Council in 1980 (Resolution XX) and today constitute the basis of PAHO's policy and programming, and represent in addition the contribution of the Region of the Americas to the global strategies of WHO.

The Plan of Action approved by the Directing Council contains the minimum goals and regional objectives, as well as the actions governments of the Americas and the Organization must take in order to attain health for all. The Plan, continental in nature, is essentially dynamic and is addressed not only to current problems but also to those likely to arise from the application of the strategies and the fulfillment of regional goals and objectives. It also defines priority areas that will serve as a basis, in developing the program and the necessary infrastructure, for national and international action.

The exchange and dissemination of information constitutes one of the priority areas of the Plan of Action. PAHO's publication program—including periodicals, scientific publications, and official documents—is designed as a means of promoting the ideas contained in the Plan by disseminating data on policies, strategies, international cooperation programs, and progress achieved in collaboration with countries of the Americas in the process of attaining health for all by the year 2000.

Emergency Vector Control after Natural Disaster



1982 Scientific Publication No. 419



PAN AMERICAN HEALTH ORGANIZATION
Pan American Sanitary Bureau, Regional Office of the
WORLD HEALTH ORGANIZATION
525 Twenty-third Street, N.W.
Washington, D.C. 20037, U.S.A.

Published also in Spanish (1982) as:
*Control de vectores
con posterioridad a los desastres naturales*

The publication of this manual, in English and Spanish, has been made possible by financial support of the Canadian International Development Agency (CIDA) and the U.S. Office of Foreign Disaster Assistance of the U.S. Agency for International Development (AID/OFDA).

ISBN 92 75 11419 6
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Foreword

Most Latin American countries are highly vulnerable to natural disasters (earthquakes, hurricanes, floods, etc.). The consequences are immediate in terms of loss of lives and suffering. Longer term consequences can include serious setbacks in national development plans.

The impact of past disasters has been enormous: Nicaragua, 1972, 5,000 deaths; Honduras, 1974, 6,000 deaths; Guatemala, 1976, 26,000 deaths. In Peru alone, the 1970 earthquake caused 70,000 deaths and approximately 170,000 casualties.

The Caribbean area is also vulnerable to natural disasters, such as hurricanes. Barbados was hit in 1955, Haiti in 1964, Dominica and the Dominican Republic in 1979, Saint Lucia, Haiti and Jamaica in 1980. Earthquakes have also occurred in Trinidad and Tobago, Jamaica and Antigua. Floods and landslides affect most of the islands. The disruption caused by natural disasters is magnified by the physical isolation of each country and the fact that, in most cases, the impact extended over the entire nation.

Disaster preparedness is a significant part of the overall strategy for achieving Health for All by the Year 2000. There is probably no event that so severely tests the adequacy of a nation's health infrastructure as the occurrence of a sudden natural disaster such as an earthquake, hurricane or flood. Especially in smaller developing countries, economic progress can also be jeopardized.

To a large extent, a solid, well-planned health delivery system that routinely includes the educated participation of the community is the most important preparation for a natural catastrophe. However, rapid recovery from large-scale natural disasters requires that special preparations and procedures be in place well before the disaster occurs. By definition, a disaster of large magnitude is one that overwhelms a community's normal response capacity.

The series of manuals on disaster preparedness issued by the Pan American Health Organization is designed to respond to the call from Member Countries to "disseminate the appropriate guidelines and manuals" so as to assist health workers in the Americas in developing disaster preparedness plans and training the necessary human resources. Given the suddenness of their occurrence and the importance of speedy measures to prevent potential morbidity and mortality, natural disasters demand that a nation use appropriate technology and its own human resources during the immediate emergency. Dependence on outside resources can create a time lag that may have serious consequences for the health and well-being of the affected population.

This manual is a companion piece to the guide *Emergency Health Management after Natural Disaster* (PAHO Sci. Pub. No. 407, 1981), and provides technical guidelines on specific chapters contained in the parent guide. The parent guide provides an overview intended to be of use to policy makers and the administrators responsible for health service delivery after the occurrence of disaster in developing nations. This manual is directed to an audience which consists of the senior technical officers involved in postdisaster health relief. Given the importance of intersectoral collaboration for effective relief efforts, the manual also provides guidelines for such cooperation.

The general principles and observations in this manual are relevant throughout the developing world. Special emphasis is, however, given to the experiences and needs of Latin America and the Caribbean. It is hoped that the manual will serve as a framework for developing national manuals, adapted to local circumstances, and that disaster preparedness will become an integrated component of national plans of action toward Health for All by the Year 2000.

Héctor R. Acuña, M.D., M.P.H.
Director

Acknowledgment

Pan American Health Organization consultants, working in the Caribbean after Hurricane David in 1979, identified the need for guidelines concerning problems related to vector-borne disease after natural disaster. This guide was prepared in response to that need. It was written for countries that might be affected by natural disasters in order to alert them of potential vector related problems and their possible solutions, and to provide guidelines for consultants assigned to countries for postdisaster assessments.

This guide was also written for individuals with a broad range of backgrounds, from that of health administration to that of vector control inspection. Certain subjects may not be discussed in sufficient detail to provide answers for all technical decisions to be made. Therefore, this information should be supplemented through additional reading of the references listed in the bibliography.

Pan American Health Organization
Working Group on Vector Control after Natural Disasters
10-14 November, 1980 Jacksonville, Florida

Members

Dr. L. J. Charles, Sr.
Public Health Consultant
Saint John's, Antigua

Dr. J. M. Lamdin
Medical Entomologist
United States Navy
Alameda, California, U.S.A.

Dr. J. A. Mulrennan, Jr.
Medical Entomologist
Department of Health and
Rehabilitative Services
Jacksonville, Florida, U.S.A.

Dr. L. L. Sholdt
Medical Entomologist
(Rapporteur)
United States Navy
Jacksonville, Florida, U.S.A.

Dr. R. T. Taylor
Medical Entomologist
Centers for Disease Control
Atlanta, Georgia, U.S.A.

Secretariat

Dr. M. Nelson
Medical Entomologist
Pan American
Health Organization
Bogota, Colombia

Dr. R. J. Tonn
Medical Entomologist
Pan American
Health Organization
Washington, D.C., U.S.A.

The Group acknowledges the valuable written contribution to the preparation of the final draft of the *Guide* made by the following:

Dr. D. Bown
Pan American Health Organization

Dr. D. Bradley
London School of Hygiene and Tropical Medicine

Dr. S. Breeland
State of Florida

Dr. N. G. Gratz
World Health Organization

Dr. H. Mathis
World Health Organization

Dr. J. Nájera
Pan American Health Organization

Dr. C. Pant
World Health Organization

Dr. L. Self
World Health Organization/Western Pacific Regional Office

Mr. J. O. Williams
Pan American Health Organization

Introduction

This guide is intended to assist governments confronted with the problems related to vectors and pests that follow certain natural disasters. It will also be of value to evaluation teams asked to determine the probability of vector-borne disease related emergencies. The specific objectives of this guide are:

- (1) To call attention to the vector, rodent, pest and related problems that may occur after a natural disaster
- (2) To provide technical information necessary for evaluating the need for vector and rodent control following natural disaster
- (3) To provide technical information for initiating immediate and post-disaster control measures
- (4) To serve as a basis for the formulation of national and international training programs for the evaluation and control of vector-borne disease after natural disaster
- (5) To provide guidelines for planning and carrying out surveillance and control programs under austere conditions.

Since every natural disaster has some unique characteristics, no guide can completely cover every situation. Individual judgment, fortified by knowledge of the environmental, public health, political and economic conditions of the affected area, will provide the real guidance for evaluating problems and finding adequate and acceptable solutions. This guide provides information about specific problems related to vectors and contains suggestions for solving them.

Part I

An Overview

Chapter 1

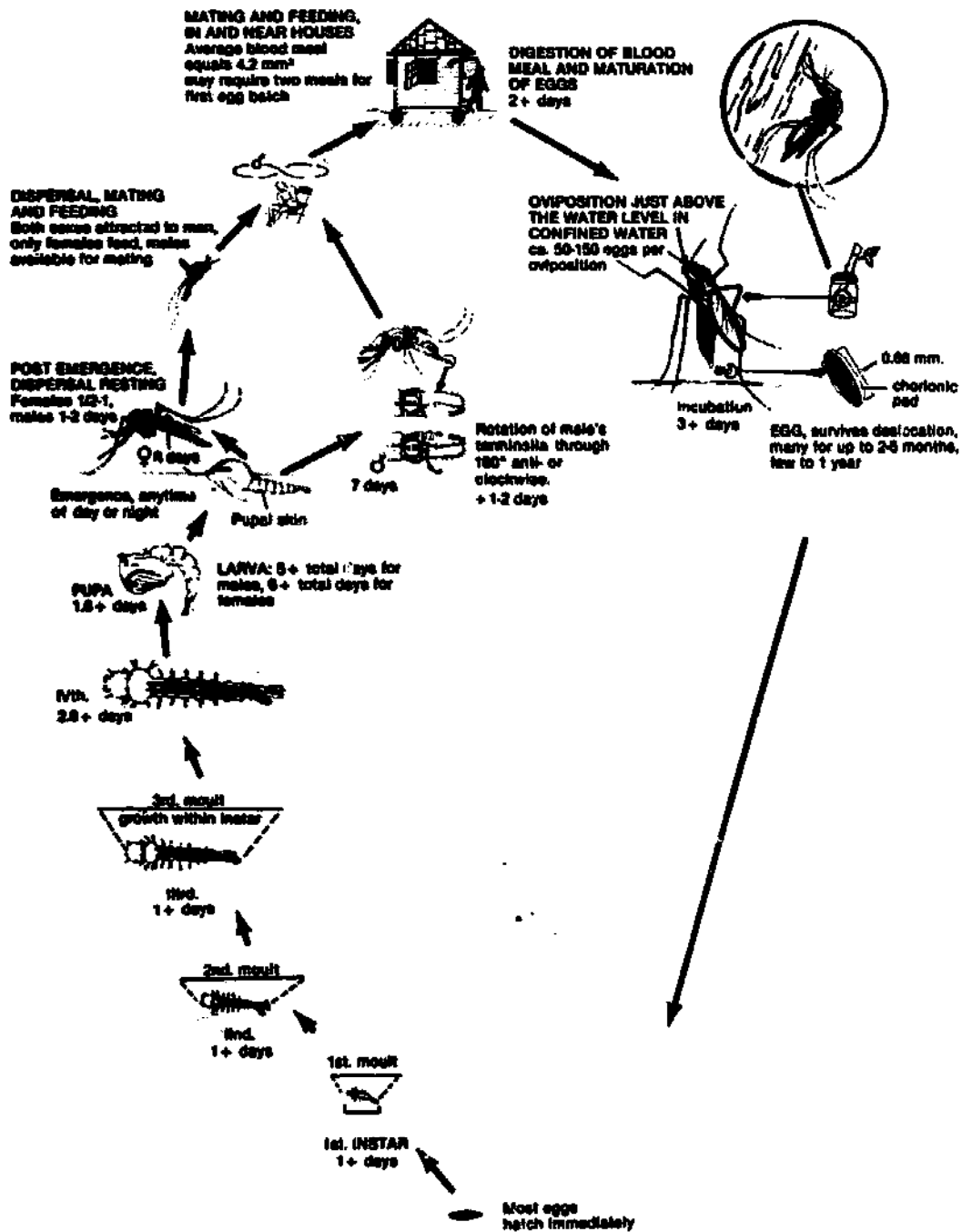
The General Problem

Although there are a number of types of natural disasters, the scope of this guide will be limited to those of hurricanes, cyclones, floods, earthquakes and volcanic eruptions. In each case, the rapidly changing environment produces a general disruption of patterns of life, which results in stress to individuals and the weakening of health throughout the population. In many instances, people are forced into crowded, unsanitary conditions which can lead to outbreaks of epidemic diseases.

For the public health administrator, sanitarian, entomologist, epidemiologist and vector control specialist, the management of health relief and related responsibilities involves careful planning. Certain natural disasters may provide sufficient warning that some of their consequences can be alleviated. Pre-disaster planning, consisting of the establishment of disaster readiness committees and the formulation of contingency plans, can limit the risk. This is accomplished through organized preparedness, including the assignment of responsibilities to specific individuals and the establishment of intergovernmental relationships through which better use is made of any existing resources. Contingency planning should, however, be broad enough in scope to allow the response to be flexible. Too much detail may be counterproductive and self-defeating. Certain guides cited in the bibliography provide administrative procedures for planning and organizing public health activities during and following disasters.

The majority of vector control programs have static, inflexible administrative procedures. Consequently, there is a tendency to respond routinely to disaster situations, even when they call for innovation and flexibility. A disaster contingency plan may alleviate some, but not all of this problem. As a result, there may be some misdirection, confusion and waste, regardless of how well organized and adaptable the program is. Overreaction to actual and potential risks of vector-borne disease may occur because of our inevitable inability

4 Emergency Vector Control



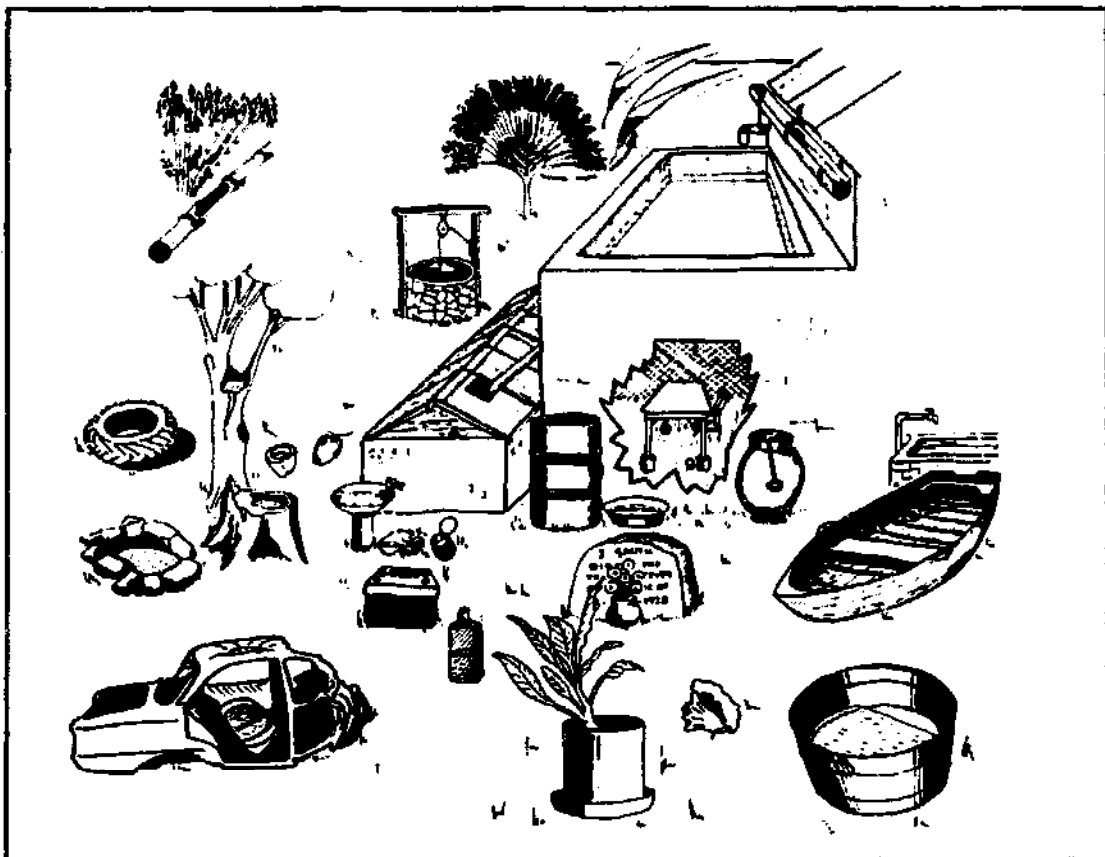
Courtesy Dr. M. Giglioli, Cayman Islands

The life history of *Aedes aegypti*.

to predict the actual future needs. That this is inevitable should be recognized in determining the availability of resources and the most effective use that may be made of them. In many cases the confusion and overreaction that takes place in the aftermath of a natural disaster will be partially offset by the visibility of entomology and rodent evaluation and control teams, whose presence may benefit the population psychologically.

Disasters do not generate "new" diseases but, by altering the environment, they may increase transmission of diseases that already exist in a region through:

- (1) Direct effect of the physical event itself, such as fecal contamination
- (2) Indirect effects which result in such conditions as overcrowding and poor sanitation
- (3) Promoting or causing increase in the movement of populations
- (4) Disrupting routine vector control programs
- (5) Altering the distribution vector species.



Courtesy Dr. M. Giglioli, Cayman Islands

Aedes aegypti breeding sites.

The increased risk of transmission of vector-borne disease must be seriously considered after all natural disasters. It is a matter of priority, therefore, that the potential of transmission of vector-borne disease is assessed early in the postdisaster period. It is important to note, however, that natural disasters do not necessarily lead to outbreaks of infectious diseases. This is particularly true of the mosquito-borne diseases, since the larval habitats and adult resting sites of mosquitoes often suffer from wind and water damage. As a result, such diseases as malaria, dengue and encephalitis may not appear until several weeks after the disaster, if they appear at all.

Chapter 2

Disaster Preparedness

A Disaster Emergency Committee, with responsibility for maintaining a state of preparedness for natural disasters, should be in existence. Such a committee would include representatives from governmental and private agencies that deal with the routine problems that are accentuated in times of disaster. A Vector Control Subcommittee should be established in the health sector, and it should be responsible for updating information concerning the status and distribution of the vector-borne diseases that are endemic to the country, as well as nearby regions. Information should be continually updated on entomological surveillance of vector populations and on the location and status of manpower, insecticides and application equipment. The subcommittee should be responsible for implementing the emergency vector control operations. To accomplish this, it must have power to act without the bureaucratic constraints that are usual in normal circumstances. The subcommittee may include individuals from a number of agencies within the Ministry of Health, as well as those from other ministries and the private sector. The chairperson of such a committee may be the officer responsible for epidemiology, for malariology or for environmental health.

In areas of high risk of recurrent natural disasters, vector control personnel should attempt to rehearse disaster emergency control operations, in order to refine procedures and develop expertise and a more effective state of alertness. Even without a Vector Control Subcommittee, insect and rodent control personnel can develop a system of alertness to function during and after disasters. Continuous in-service training of all members of the staff should be included in all control programs. Training and program evaluation services offered by the Pan American Health Organization can assist administrators in identifying and resolving problems in control programs.

The vector control program should keep information current on the following:

- (1) The status of all instruments, aids and activities necessary for surveillance, evaluation, and control activities, including:
 - (a) Distribution maps of areas of high risk of disease transmission, which delineate the sizes of vector populations, increases in larval breeding sites and the locations of potential reservoirs of disease
 - (b) The distribution of all cases of malaria of autochthonous and foreign origin
 - (c) Maps of the phases of progress in malaria and *Aedes aegypti* control programs
 - (d) Population indices for *Aedes aegypti*, malaria vectors and other important species
 - (e) Graphs of monthly variation in vector density per year and according to changes in rainfall and temperature
 - (f) Graphs showing changes in the incidence of vector-borne and rodent-borne diseases
 - (g) Status of seaport and airport *Aedes aegypti* and rodent surveillance programs.
 - (2) The inventories of insecticides and vehicles and other types of equipment, and lists of personnel and variable funds, including:
 - (a) Breakdowns for each vector and rodent control program
 - (b) A list of similar or related programs that exist in other ministries, such as Agriculture and Defense, and an inventory of their equipment and insecticides that can be converted to public health use
 - (c) A list of private fumigation and agricultural spray companies that have ultra-low volume (ULV) and other application equipment (which might be owned by resorts or cities in touristed areas)
 - (d) A list of the names, telephone numbers and addresses of contacts in the Ministry of Health and other ministries and, in addition, of companies that supply and manufacture insecticides and dispersal equipment, and of international representatives
 - (e) A list of any other known, local sources of expertise, supplies and material.
 - (3) The status of transportation, communication and intelligence, and other maps and reports that might assist in reconnaissance and other types of surveys, including:
 - (a) Road maps of larger political divisions and street maps of cities and towns
-

- (b) Geographical and topographical maps
 - (c) Aerial photography surveys of high risk areas of vector-borne diseases
 - (d) Distribution maps of agricultural products
 - (e) Telephone directories, airline schedules and ham radio operators, and radio, television and newspaper services
- (4) Directions for routing requests for interdepartmental and international aid, and a list of agencies.
- (5) An operational contingency plan.
-

Chapter 3

Postdisaster Action

Immediate Action

One of the first actions of the subcommittee should be to assess the potential of vector and rodent related problems, and to gather adequate baseline information. Vector and rodent control personnel should be consulted about the locations of temporary living quarters, so that human contact with these organisms is minimized. Vector and rodent control personnel, and sanitarians, can also provide advice about mosquito and rodent proofing of temporary structures. It is also necessary at this time to determine if the available staff members, insecticide resources and equipment are adequate. If not, appropriate measures should be taken.

Assessment of Situation

A significant problem that administrators of vector control face after natural disasters is accurately assessing the potential of vector and rodent related problems, and determining what resources are required. A considerable amount of unreliable information concerning the vector problem may be generated from other than official sources. In most cases, it will be exaggerated and panic may result in the population. Accurate and updated information collected before a disaster facilitates the proper evaluation of the postdisaster situation and it aids in the process of making logical decisions concerning a plan of action. Such information also helps in providing international relief agencies a clear picture of the problems a disaster can pose. It permits them to reach a clearer definition of their role in relieving shortages of insecticides, rodenticides and equipment. Adequate information from the predisaster period also improves the accuracy of the information that is given to government information services and the local population.

Each of the different types of natural disasters causes specific kinds of vector and rodent related problems, and the periods of time in which they remain problematic varies. This is particularly true of water related disasters that create breeding habitats. Certain types of information, which may be broken down according to type of disaster, are generally required in the postdisaster period. After all disasters, it is necessary to do the following:

- (1) Determine the geographical area and the size and distribution of the population affected, and the political and medical zones involved
- (2) Assess the extent of damage to transportation and communication systems
- (3) Determine the availability of staff, the availability and condition of equipment and supplies in the affected area, and the availability of additional resources in unaffected areas
- (4) Review the current information on the vector and rodent situation, including population densities in the affected area and the prevalence of vector and rodent related diseases in affected and adjacent areas.

After the specific occurrence of water related disasters, such as hurricanes, cyclones and floods, the following steps need to be taken:

- (1) Determine all migrations and redistributions of human populations within and adjacent to the affected area
- (2) Assess the extent of damage to the water supply system and sanitary facilities, and estimate the time required to restore these services
- (3) Appraise the crowding and exposure to mosquitoes and other vectors in postdisaster living situations, and the rodent-ectoparasite contact and fly breeding as they relate to the living situations
- (4) Determine the status of established mosquito breeding habitats and the extent to which new ones are created
- (5) Work with epidemiologists and other health officials to reestablish the disease surveillance network and the role of the vector control programs within the network.

When earthquakes and volcanic eruptions occur, these steps should be followed:

- (1) Determine population movements and the need for shelter, water and sanitation
 - (2) Assess the risk of vector and rodent-borne diseases
 - (3) Determine the need for vector control when there is emergency provision of water and sanitation in the area.
-

Aerial observation, where available, is one of the easiest methods of obtaining information on the geographical extent of damage to population centers and communication and transportation systems. It is useful, as well, for assessing vector breeding potential and human population movements. Light, single and multi-engine aircraft and helicopters may be available from the military and private sectors or from commercial agricultural aerial spray companies. Funds for aerial surveillance should be allocated in any budget. Maps and, if available, recent aerial photographs can be used for comparative purposes when the situation is assessed.

Additional information may be obtained from on-site reports from vector control staff members who live or work in the area and from local public health inspectors, physicians, administrators and teachers. Some caution should prevail, however, when interpreting information from these sources.

Determining Priorities of Action

Knowledge of the biology and ecology of pest organisms and their relevance to the current conditions is required when the effect that natural disaster damage has on vector and rodent problems is assessed. For example, flooding usually flushes out or destroys mosquito breeding sites. It subsequently creates additional habitats that can eventually produce even greater mosquito densities. When water and sewage systems are damaged, increased storage of potable water can provide additional breeding sites for *Aedes aegypti* while temporary pit latrines can provide habitats for synanthropic flies and *Culex quinquefasciatus*. Inadequate food storage, poor sanitation, and contamination by debris, animal carcasses and excreta may produce filth flies and increase the visibility of the rodent populations.

Problems related to vectors and rodents may not be confined to the affected region. Human movement away from the region may contribute to crowding in peripheral areas and, as a result, provide opportunity for proliferation of diseases associated with vectors and rodents. Following water related disasters, the peripheral areas may harbor potential mosquito breeding habitats that are more conducive as immediate oviposition sites than in the actual disaster area.

When setting priorities, types of vector-borne diseases in the area and density of the human population are factors to consider. When these are known, action should be immediately directed toward the areas of high population density, especially slum areas and camps where migrant populations are received. Every attempt should be made to restore and strengthen routine vector control operations within the area.



Photo courtesy L. Scholdt

Cisterns, cans, bottles, cemetery urns, tires and almost any discarded container that holds fresh water may become a vector breeding site.

Under certain circumstances, the Ministry of Defense may be called upon to render aid in the wake of a natural disaster. Probably no other organization is so uniquely endowed with the necessary resources such as manpower and transportation, and possesses the necessary capability of quick reaction.

Urban, suburban, and rural areas of high priority for receiving control efforts should be determined from the following criteria:

- (1) Population at risk
 - (2) Number of confirmed or suspected disease outbreaks
 - (3) Recent history of disease transmission
 - (4) Relative density of potential disease vectors
 - (5) Significant increases in new breeding sites
 - (6) Significant wind damage resulting in destruction of sprayed houses and increased exposure of displaced or homeless persons to mosquitoes
 - (7) Presence of potential disease reservoirs
 - (8) Seasonal accessibility by ground transport
 - (9) Number and types of complaint calls regarding mosquito activity.
-

Surveillance and Control

The major activities in vector and rodent control occur during the post-disaster period. If the immediate surveys and other sources of information indicate a potential problem, the sooner that postdisaster programs are implemented to reduce the disease potential, the less is the chance that epidemics will occur and the less is the overall expense to the government. Delaying action until an epidemic is at its height can be medically and economically disastrous.

Reestablishing and upgrading routine control operations, surveillance activities and training of staff members will go far in lessening the chance and/or impact of an arthropod-borne epidemic. Operational manuals for control of malaria and *Aedes aegypti* caused diseases prepared by the World Health Organization and the Pan American Health Organization can assist in planning these activities.

Emergency Action in the Event of a Vector-Borne Disease Outbreak

Should the immediate action to bring vector populations under control prove insufficient, and a vector-borne disease outbreak result, all efforts should be made to reduce infective adult mosquito populations as soon as possible, by such space spray methods as aerial ultra-low volume (ULV) applications, vehicle-mounted and portable thermal foggers, aerosol generators or portable mist ultra-low volume blowers. Details about these methods are given in Part II. under "Specific Vector Problems."

Chapter 4

Vector and Rodent Related Diseases

Mosquito-borne diseases, especially malaria, dengue and arboviral encephalitis, cause significant concern after disasters with which heavy rains and flooding are associated. The *immediate* effect is, however, the probable destruction of larval habitats and some accompanying reduction of the vector population with the secondary creation of new larval habitats. It is difficult to determine the probability that greater adult densities will be produced in these habitats and, subsequently, whether an increase in disease transmission will occur.

Such vector related diseases as endemic typhus and certain rickettsial diseases, should cause concern when they are already endemic in or near a disaster area. In addition, fly, cockroach, bedbug, human louse and rodent infestations may pose problems. Immediately after a natural disaster, the fly and rodent densities may appear to be greater, either because they become more visible or have indeed rapidly increased. This is partly due to disruption of sanitary services, such as garbage collection and disposal, and also because increased human crowding is accompanied by increases in the densities of populations of rodents and other vermin which seek the same sources of food and accommodation.

In some regions of the world, unsanitary and crowded temporary shelters and inadequate facilities for storing food provide ideal habitats for bedbugs, lice, fleas, mites, mosquitoes and rodents. Under conditions of this sort, the possibility of transmission of diseases such as louse-borne epidemic typhus, plague and malaria is enhanced.

The potential for increase of vector-borne disease occurrence and related problems during a postdisaster period is summarized on the next page. The immediate period is one to seven days after impact. The "delayed" effects refer to those that occur during the next 30 days or more.

The following sections will cover the issues of identification, evaluation and control of specific problems. The reader interested in routine control operations related to specific diseases, should consult the bibliography.

Vector	Immediate	Delayed
Filth flies	annoyance	diarrhea, dysentery, conjunctivitis, typhoid, cholera, fly larvae infestation, annoyance
Mosquitoes	bites and annoyance	encephalitis, malaria, yellow fever (urban), dengue, filariasis, annoyances and bites
Rodents	rat bites	rat bite fever, leptospirosis, salmonellosis, rat bites
Lice	bites and annoyance	epidemic typhus, louse-borne relapsing fever, trench fever, bites and annoyance
Fleas	bites and annoyance	plague, endemic typhus, bites and annoyance
Mites	bites and annoyance	scabies, rickettsial pox, scrub typhus, bites and annoyance
Ticks	bites and annoyance	tick paralysis, tick-borne relapsing fever, Rocky Mountain Spotted Fever, tularemia, bites and annoyance
Bedbugs, Kissing bugs	bites and annoyance	bites and annoyance Chagas' disease
Ants, spiders, scorpions, snakes	envenomization, bites and annoyance	envenomization, bites and snakes, bites and annoyance

¹From 1-7 days²30 days or more

Part II

Control Measures for Specific Vectors

Chapter 5

Aedes Aegypti

Aedes aegypti is the vector of dengue, dengue hemorrhagic fever and urban yellow fever. It is a domestic mosquito that breeds in artificial containers in and around human dwellings. As containers proliferate, the species achieves high levels of density. This mosquito has also been known to breed in artificial containers placed some distance from human dwellings, and in natural containers, such as tree holes, bamboo, coconut shells and large snail shells. Any given area has slightly unique breeding habits, due to differences in the habitats and lifestyles of humans. In areas where water is stored or collected, open containers furnish ideal habitats. Such breeding sites should be given extra attention after a natural disaster, especially if the normal water supply is disrupted. Cisterns, cans, bottles, cemetery urns, tires and almost any discarded container that holds fresh water may also become infested.

The adult female mosquito deposits its eggs singly on the side of the container at, or immediately above, the waterline. Rains associated with some disasters provide the needed water to allow hatching, because the eggs are able to withstand drying for several months. Excessively heavy rains quite often wash away much of the initial egg deposition. However, large numbers of *Aedes aegypti* are quickly produced in numerous new oviposition sites. When conditions are favorable, hatching can occur within two or three days after ovipositioning.

Larval development, under favorable conditions, can be completed in five to seven days. The fourth instar larva molts to a pupal stage, and transformation to an adult is completed during the two to three day pupal period. Consequently, the life cycle can be completed in about ten or more days.

The emerging adults usually do not disperse more than a hundred meters and the females will readily enter nearby houses or any other man-made dwelling. In order to develop eggs, females require a blood meal for which

humans are the preferred host. Biting usually occurs during, but is not limited to, daylight hours. In many cases humans are not aware of being bitten. The adult may live for six to eight weeks and, once infected with the viruses of yellow fever or dengue, remains so for life.

Surveillance

If the country has an eradication or control program for *Aedes aegypti*, baseline information on population densities in the affected or adjacent areas should be available. Wherever there is no control program, the distribution of the vector should be mapped, its favorable larval habitats should be determined and adult population densities should be studied by determining land rates and the distribution and examination of oviposition traps.

Initiation of new or additional control activities should be related to the prevalence of *Aedes aegypti* or virus activity in the immediate and nearby areas. The epidemiologist should be responsible for determining the presence or likelihood of the introduction of diseases.

Recruitment and training of new vector control personnel may be problematic and depends in part on the budgetary priorities of the government. Even with assistance from external sources, tremendous strain is placed on budgets during natural disasters. If paid personnel are unavailable during emergencies, military recruits, school children, boy scouts and other volunteers may be used.

Backup availability of laboratories is necessary for identification of mosquitoes. This may be available from an *Aedes aegypti* or malaria control service. Universities and other research institutions might have a professional entomologist or student biologists capable of making taxonomic identification. All surveillance programs must have maps, office space, and clerical and other technical and administrative assistants to organize and evaluate field data. Information from the program should be made available to vector control and epidemiological personnel as soon as possible.

Estimates of Larval Populations

Even though adult populations are the most important of the populations of *Aedes aegypti*, when personnel trained to make species identification are available, the surveillance of larval populations is easier and more reliable than that of adults. The systematic collection of larvae serves to determine the presence, distribution and relative abundance of *Aedes aegypti*.

Estimates are usually limited to those obtained when the frequency of *Aedes aegypti* larvae in water-filled containers in the vicinity of occupied buildings is assessed. Larvae can, however, be found in containers in vacant lots and along roadsides.

Surveys can be rapidly performed in several manners. Biases in information gained can be minimized if: (1) blocks to be surveyed are selected by a randomized procedure and then all houses on the selected blocks are investigated, (2) every third (or some other ordinal number) house is systematically investigated, and (3) fifty or more houses per subdivision are placed randomly in the sample.

One or more collectors, who search for and examine all water-filled containers in the vicinity of occupied buildings, take part in surveys for larvae. During the initial survey, the species composition should be determined through the collection for laboratory identification of one larva from each positive container ("single-larva-per-container survey"). Simple inspection,



Photo courtesy L. Scholdt

The surveillance of larval populations is easier and more reliable than that of adults. Larvae are collected with a white enamel dipper, white enamel pans or other water containers, or a siphon. Flashlights or mirrors can be used to illuminate breeding places and to locate water and evidence in breeding.

or "visual larvae surveys," may suffice thereafter. Each individual who participates in the survey will need the following:

- (1) Forms and pencils
- (2) A flashlight
- (3) A small mirror
- (4) A dipper (if possible made of white enamel)
- (5) A squeeze-bulb syringe or medicine dropper for transferring larvae
- (6) A tea strainer to remove larvae from debris or dark water
- (7) Collection bottles and a wax or grease marking pencil
- (8) A container or bag to carry the instruments and equipment.

The results of the surveys are usually expressed in terms of one or more of the following indices:

- (1) The House Index (or premises Index), in which the percentage of the houses examined and found positive for *Aedes aegypti* larvae is reported
- (2) The Container Index (or receptacle Index), in which the percentage of the water-holding containers that were examined and found positive for *Aedes aegypti* larvae is reported
- (3) The Breteau Index, in which the total number of containers with *Aedes aegypti* larvae is described per hundred houses.

Criteria for interpreting the probability of the transmission of yellow fever by *Aedes aegypti*, from the results of such surveys, have been published in the *World Health Organization Weekly Epidemiology Record* (49, 1971:493-500). Urban transmission of yellow fever is unlikely if the Breteau Index is less than five, the House Index less than four and the Container Index less than three. But where these figures are, respectively, greater than fifty, thirty-five and twenty, there is a high risk of transmitted yellow fever. Comparable criteria have not yet been established for dengue, but a similar interpretation of the indices may also be valid. In both cases, the indices of *Aedes aegypti*, the transmission of virus and the level of immunity in a population are related.

Estimates of Adult Populations

Adult surveillance is particularly appropriate in areas where it is necessary to quickly assess the effect of an emergency adulticiding operation. There are both direct and indirect methods of sampling adult *Aedes aegypti* populations. The direct methods vary in their degree of difficulty in interpretation of data. Three direct methods may be employed: resting, landing and sheet drop collections.

Resting collections may be recommended over landing counts, especially if dengue has been reported to a substantial extent in the area. Resting collec-

tions consist of search for adults in bedrooms, and other rooms in houses, garages and outbuildings. They may also be performed in yards, cemeteries, tires and junkyards. The adults are captured with small vials, hand sweep nets, or mouth or battery powered aspirators. The adults usually rest in shaded places and dark corners on walls, clothing, or mosquito nets, and under tables, chairs, or beds. *Aedes aegypti* can be found resting throughout the day so there is no restriction on time of day in which they may be collected. The collector should spend a certain standardized period of time, such as 20 minutes, in each house. This allows density to be expressed in catch-per-house and catch-per-man-hour. Mosquitoes are identified by species and sex. Collection stations can be selected at random, or they can be located at predefined sites. It should be remembered that collecting depletes the population and thus, that the same house should not be sampled every day.

Landing counts are made on humans. Thus, a collector can collect either from his own body or that of a second person, if collectors are working in pairs. Trials should be made before initiating this type of survey *and the methods to be used should be standardized* because individuals vary in attractiveness to mosquitoes. It is recommended that a twenty-minute collecting period be made in each house, between the hours of 0900 to 1100, and that the results be expressed in terms of catch per man hours.

The following items of equipment are required for adult surveys:

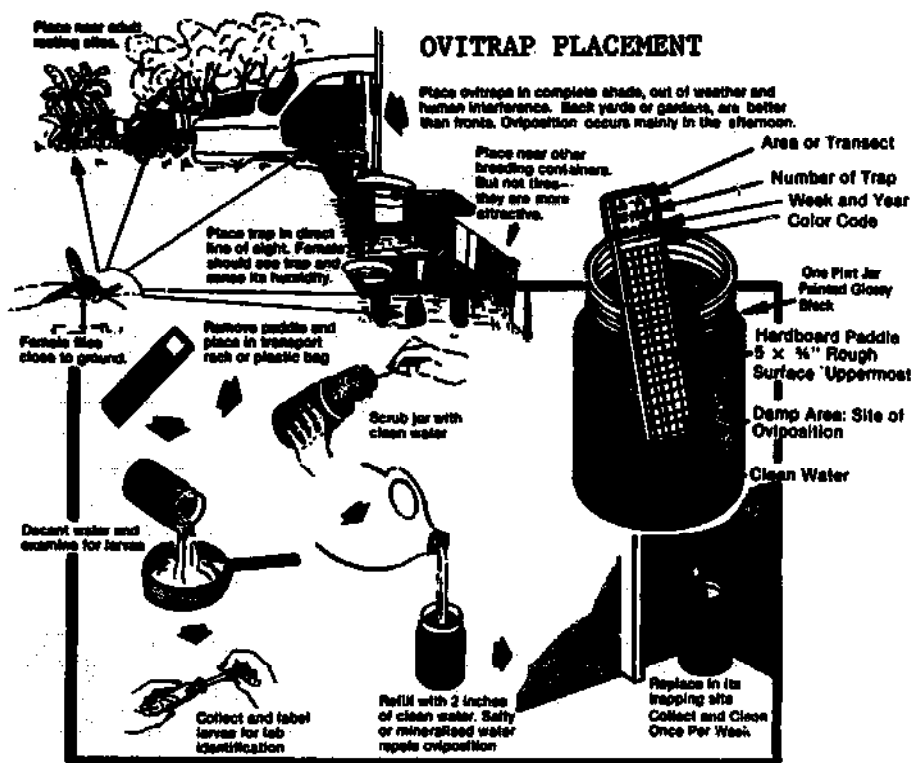
- (1) Forms and pencils
- (2) Flashlight
- (3) Vials
- (4) Aspirator
- (5) Sweep net.

If a knockdown aerosol is available, the *sheet drop technique* is a quick and easy method of obtaining a representative sample of adult mosquitoes inside dwellings. In this technique, a white sheet is spread out on the floor and over the furniture of an occupied room, and then the occupants are asked to leave for approximately fifteen minutes. The room, made as airtight as possible, is sprayed with the knockdown aerosol. After having left the room for ten minutes, the collector enters again to collect all the mosquitoes that have dropped on the sheet.

It is important to make certain that collection procedures are standardized; otherwise, results that should not be compared will cause incorrect conclusions to be drawn about changes in populations. Collections at a simple location should be performed by the same individuals, in a uniform manner, and at the same time of day. The number of houses to be sampled can be decided on-site.

Ovitrap provide an indirect method of assessing the presence and size of the adult *Aedes aegypti* population after a natural disaster. This method is particularly good for detecting the presence of *Aedes aegypti* where the density is so low that larvae are difficult to find. Ovitrap cannot be used to effectively measure adult population densities, but if they are used routinely they can indicate changes in the population.

Ovitrap consist of black-enamelled, one-pint glass jars (of 130 mm height and 75 mm diameter). Almost any wide-mouthed glass jar with a glossy black ceramic paint on the outside can be used. Tin cans, beer cans or bamboo pots can be substituted for glass jars, but the same type of container must be used throughout the study. Clean water is added to a depth of two to three cm and a paddle is clipped vertically to the inside of the jar. The paddle should be made with an absorbent material; porous hardboard is recommended, but heavy cardboard, heavy velour paper or cloth can be used. When it has absorbed water, the paddle is an attractive surface on which mosquitoes deposit eggs. The size of the paddle should be standard, for example, 2 cm by 13 cm. The rough surface of the paddle should face the center of the jar. Paddles are usually changed at intervals of five or seven days; however, the exact schedule that should be used depends upon the number of positives identified per collection.



Courtesy Dr. M. Giglioli, Cayman Islands

To obtain the full benefit of ovitrap surveys, the area should be fairly extensively covered. Maps should be consulted for deciding locations in which to place the traps, and visits should be made to the area for selecting the sites. Transects or grids should be used in the survey. It is recommended that sites should be from one to two hundred meters apart, and that the traps are placed within thirty meters of the grid line.

Points to be considered are:

- (1) The traps should be placed at or near ground level because females usually fly near the ground
- (2) Traps should be visible to the female mosquitoes that fly over them
- (3) Traps should not be placed where they will fill by rain
- (4) All traps should be placed where children, cats, dogs and other small animals do not have access to them
- (5) Ovitrap jars should be located in partial or total shade, in adult resting places such as shrubbery or junk. Placing them in the rear of a house is preferable to placing them in the front
- (6) Females tend to prefer tires to ovitraps, so ovitraps should not be located in tire yards or near other locations where tires are piled.

When the paddles are collected, the water should be changed and the inside of the jar should be wiped clean. Ovitrap jars should be assigned numbers or otherwise marked with an identifying code. Paddles should be dated and should



Photo: J. Moquillaza

A vector control worker in Honda, Colombia, checks ovitrap for evidence of *Aedes aegypti* infestation.

also be marked according to the code. If collectors miss a site, the date will help the laboratory technician in recording information. When transported to the laboratory, paddles may be placed in a plastic bag or wrapped in toilet tissue or other soft paper. Some workers have designed carrying cases similar to microscope slide boxes for the transporting of paddles.

The occurrence, distribution and changes in population density of *Aedes aegypti* in an area are revealed by the presence of its eggs on ovitrap paddles. All mosquito eggs found on the paddle might not, however, be *Aedes aegypti*.

If there is a question concerning accuracy of identification of the eggs, they should be hatched so that the larvae can be identified. Some workers recommend counting all of the eggs on the paddle; however, for disaster followup the mere recording of the presence or absence of *Aedes aegypti* eggs should be sufficient.

Control of *Aedes aegypti*

Ideally, *Aedes aegypti* populations are controlled through rigorous environmental sanitation and the availability of a piped water supply that eliminates many of the man-made habitats of the species. In a postdisaster period, the disruption of existing water supplies causes people to store increased quantities of water in containers, thereby increasing the availability of man-made habitats.

The appropriateness of measures for the emergency control of *Aedes aegypti* that should be taken after a natural disaster depends upon the presence or absence of dengue or yellow fever in the affected area, and upon the population density of the vector. As stated previously, larval habitats may be flushed out or destroyed during a disaster. Nonetheless, if rains occur during or after the disaster, new larval habitats may be created. However, it may take several weeks before the mosquito populations reach such a level that there is concern that disease will be transmitted. This lag in time should be sufficient for the initiation of routine control activities and for sanitation crews to haul away or empty many of the potential larval habitats. Through health education, the public should be asked to cooperate in a source reduction campaign especially since community involvement may be at a high level after a disaster. This is a key ingredient in a successful *Aedes aegypti* borne disease prevention program.

Larval Control

If the risk to health is immediate prior to the emergence of appreciable number of adults, source reduction will be recommended. The success of this type of campaign will depend upon the extent of organization, discipline and ade-

quacy of number of staff members, and upon the completeness of the treatment of potential larval habitats. The Pan American Health Organization *Manual of Operations for an Aedes aegypti Eradication Service* can be consulted for basic organization of a campaign.

There are two insecticides that can be used for treating containers which hold potable water: one percent temephos (Abate[®]) sand granules and methoprene (Altosid[®]) miniquets. In many parts of the world temephos has been used as a larvicide for a number of years. Its effectiveness usually lasts from one to three months; an eight-week treatment cycle is recommended. The treatment dosage of temephos is 1 ppm. There may be objections made to the taste of the treated water, but these may be counteracted through public relations efforts.

Methoprene, an insect growth regulator, has been placed on the market only recently. Odorless and tasteless, methoprene is considered to be safe for use in potable water. It has been successfully used in Thailand, Indonesia, and Venezuela. The label must be consulted to determine proper dosage of the miniquets, which are available in a number of sizes. Since the period in which methoprene remains effective is considered to be shorter than that of temephos, a four-week treatment cycle may be necessary.

Both the temephos and methoprene insecticides can be used to treat watering containers used by animals. In many cases, however, it is unnecessary to treat containers used by animals with insecticides because frequent cleaning and changing of the water leads to effective control over the mosquito.

Other insecticides or formulations can be used for the treatment of larval habitats that are not in close association with man. As a temporary measure, tin cans and other containers can be treated before they are removed with emulsifiable concentrates and wettable powder insecticides applied with hand-operated compression sprayers and power spray equipment. Insecticides such as fenthion, temephos, pirimiphos-methyl, malathion, fenitrothion, chlorpyrifos, and methoxychlor may be used as well as diesel fuel, kerosene, and proprietary mosquito-control oils. The product label should be consulted about the rate of application and the safety recommendations. Since some of the products are highly toxic to mammals, operators should strictly observe the precautions. It is essential to prevent toxic or ecological accidents by very clearly defining the dosage to be used and the places to be treated.

Adulticiding

Efforts to control adult populations of *Aedes aegypti* in dwellings with residual sprays are not generally effective since as few as ten percent of the adults rest

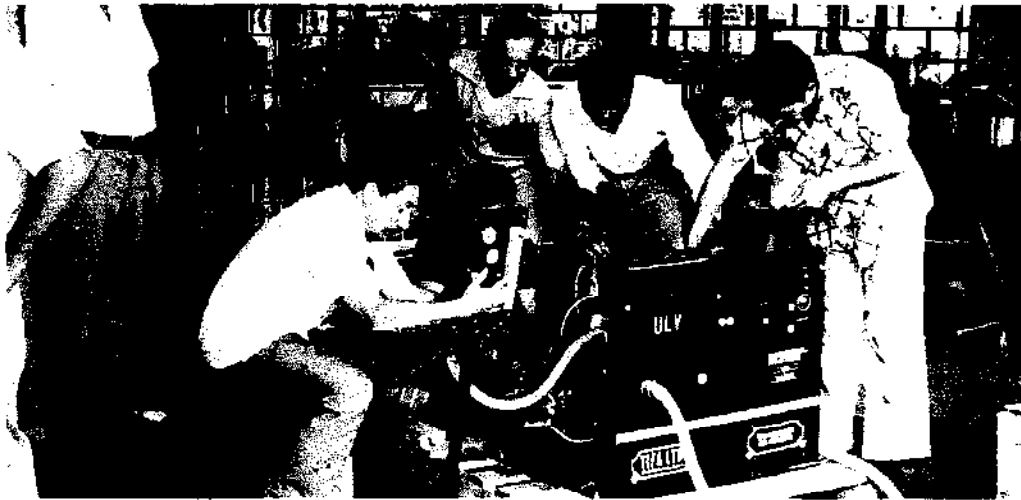


Photo: J. Moquillaza

Vector control team assembling ULV equipment in Venezuela. Ultra-low volume space spraying can be used to control urban and salt marsh pest mosquitoes as well as *Aedes aegypti* and malaria vectors. ULV applications are rapid, and are also less expensive than thermal fogs.

on the walls at any point in time: most rest on clothes, pictures, bedspreads, mosquito net poles and other objects. Residual spraying is also slow. As an effective means of *Aedes aegypti* control in urban areas it is, therefore, of doubtful value. However, it may be of greater usefulness in refugee camps. There, pirimiphos-methyl, malathion, resmethrin and synergized pyrethroids can be used. Again the manufacturer's instructions should be strictly followed.

Adulticiding, in conjunction with larviciding, will more rapidly cause decrease in the population. Use of modern application equipment can increase coverage and should be considered when (1) either dengue or yellow fever is endemic to the area, or at epidemic levels in the vicinity, (2) there is already an *Aedes aegypti* operational program in which this equipment is used and has effectively brought the *Aedes aegypti* populations under control, and, (3) the larviciding program is ineffective.

One problem that use of modern equipment poses is logistical. If the equipment is not readily available, considerable time may be lost while waiting for its arrival. Vehicles are usually taxed to the limit after a disaster, and unless vector-borne epidemic is imminent, they are usually put to other more urgent purposes than transporting modern equipment. Other problems posed by the use of modern equipment, especially in newly created programs, concern the lack of trained staff, inadequate organization and the tendency to attempt too much with limited equipment and resources. Use of modern equipment does

not always entail simply negative aspects, however; it may create beneficial psychological effects, and the use ultra-low volume aerosols and thermal fogs is speedy and efficient.

A number of companies manufacture ground and portable space-spray equipment (see Annex IV). When these are utilized, the manufacturer's instructions for the operation, maintenance and calibration of the equipment should be followed. Usually, aircraft equipment that is used in agricultural work is adapted to public health use.

Thermal fogging is the oldest of the two space spray methods. The equipment used for thermal fogging can be vehicle-mounted and portable. The portable equipment should not be used in indoor applications because it can create fire hazard. The outdoor machines are rather noisy and the fog can create a traffic hazard. There are also the disadvantages of the need to purchase and transport large quantities of nonactive oil carriers and the possible thermal decomposition of the insecticides. Despite these problems the machines are popular and provide an acceptable level of control. Thermal fog applications of chlorpyrifos, fenthion, fenitrothion, malathion, naled and pyrethroids have all shown promise in the control of *Aedes aegypti*. Concentrations, dosages and safety handling procedures should follow the recommendations on the label of the manufacturer.

In emergencies, one or two portable thermal foggers can be mounted on a vehicle, which serves as a mobile unit. The sizes of *Aedes aegypti* populations generally decline sharply within a few hours of fogging; the adults, however, reappear within a day or two. Treatment schedules should be adjusted accordingly.

The use of ultra-low volume equipment for the application of low dosages and volumes of undiluted, or partially diluted, insecticides has steadily increased. Ultra-low volume applications are rapid, and are effective against *Aedes aegypti*. They are also less expensive than thermal fogs because the cost of the solvent or carrier and of the transportation of thermal fogs is unnecessary.

Many control programs have had good results with vehicle-mounted, ultra-low volume cold aerosols, which are available from a number of companies (see Annex IV). Chlorpyrifos, fenthion, fenitrothion, malathion, naled, pirimiphos-methyl, and pyrethroids such as resmethrin have been used. Although initially expensive, these are relatively free of problems, and they can be operated for several years. The generator can be mounted on any one of a number of different types of vehicles. The type of vehicle that should be used will depend upon road conditions, which also determine whether or not a heavy-duty, four-wheel drive or a light, two-wheel drive vehicle should be used.

It should be noted that not all of the breeding and resting places of *Aedes aegypti* can be reached by road. Equipment should, therefore, include the portable or backpack ultra-low volume equipment. It is available from a number of manufacturers (see Annex IV). The performance of some of these approaches that of true ultra-low volume, while others merely have manufactured nozzle modifications for mist blowers. Since the latter equipment is used extensively in agriculture, this may provide a source of equipment during emergency situations. Although with portable equipment there is a tendency toward overdosing, it has been noted that overdosing produces a short-term residual effect that can be advantageous during disaster related emergencies. There should be two spraymen, working in shifts of thirty minutes, assigned to each piece of equipment. Workers should be provided protective gloves, respirators and clothing. Their uniforms should be changed daily and should be washed after each use, and, if possible, monthly routine cholinesterase determinations should be made on all spraymen.

Aerial ultra-low volume application is exceedingly rapid, and has been reported to be successful. Aerial applications have been successfully used in Puerto Rico, Mexico, Trinidad, the Bahamas, Honduras, and Jamaica for control of *Aedes aegypti* during dengue epidemics. Success of application, however, depends on the expertise with which it is performed. Aerial ultra-low volume application can be performed by specialized companies under contract. These companies generally use multi-engined aircraft that are capable of transporting insecticide over a great distance. The relatively large size of these airplanes makes it possible to treat a large area at one point in time. It is preferable to select companies that are experienced in public health spraying. Highly skilled pilots should be trained to carry out applications at the proper speeds and heights.

The single-engined aircraft and the helicopters that are used to apply insecticides and herbicides for agricultural purposes should also be considered for use of ultra-low volume application. Local and civil aeronautic regulations may restrict the use of such aircraft, but waivers can usually be obtained for some emergency usages. If aircraft used for agricultural purposes are employed, it should be noted that there is much greater coverage per acre/hectare of ultra-low volume application of pesticides than there is when agricultural pesticides are applied. Thus, the costs should not be the same. It should also be noted that the pilot of the aircraft may have to practice the application of the public health insecticide before it is actually carried out, because the method by which it is applied differs from that used for agricultural purposes.

The insecticides that can be used in aerial ultra-low volume application are malathion, fenitrothion, naled, pirimiphos-methyl and resmethrin. Unless there is an indication of resistance, or other insecticides are more readily available, an ultra-low volume formulation of malathion applied at 219 ml/ha to 440 ml/ha (3 to 6 oz.) is recommended. Multiple treatment is usually required for effective control, and entomological evaluation should be undertaken to decide upon frequency of treatment. If this is not possible, the insecticide should be applied weekly or twice-weekly, until the adult *Aedes aegypti* population is negligible.

When insecticides are applied, it is important to follow the instructions on both the equipment and the insecticide label. There are also a number of other factors which should be known if the equipment is to be safely used, and if it is to perform efficiently. One consideration concerns the droplet size of the insecticide. Droplets that are too small tend to drift out of the target area and may present a respiratory hazard, while allowing droplets to be too large wastes insecticide and may lead to damage to automobile paint. Nozzles for ultra-low volume ground equipment should be capable of producing droplets in the 5- to 27-micron range at the minimum. For malathion, the mass median diameter (MMD) should not exceed 17 microns. These limits change when the insecticide is applied from aircraft. When malathion is aerially applied, the nozzles should be capable of delivering droplets less than 50 microns (MMD); when naled is aerially applied they should be capable of delivering droplets of less than 30-80 microns (MMD).



Photo: J. Moquillaza

Portable backpack mistblowers such as the one above being demonstrated in Venezuela, are useful for adult control of *Aedes aegypti*, *Culex* sp, and malaria vectors, especially when breeding and resting places cannot be reached by road.

The speed and time of application are important to consider when insecticide is applied by ground vehicle. The vehicle should not travel faster than 16 kilometers (10 miles) per hour, and when wind speed is greater than 16 kilometers (10 miles) per hour, or when the ambient air temperature is greater than 28°C (82°F), the insecticide should not be applied. The best time for applications is in the early morning approximately (0600-0830 hours) or late afternoon (approximately 1700-1930 hours). However, operations during the entire evening are applicable to *Culex* and pest mosquito control.

The information that should be known about aerial application of insecticides varies according to the types of aircraft, insecticide and equipment used. For application of malathion, the altitude of the aircraft should be between 30 to 65 meters (90 to 150 feet) and aircraft speeds should be between 160 to 260 kilometers (100 to 162 miles) per hour. Swath widths will vary according to the altitude. Early morning applications are preferable to application at other times of day. Temperatures should be less than 27°C (80°F) and wind velocity below 16 kilometers (10 miles) per hour. In addition, there should be a temperature inversion (when ground temperature is cooler than air temperature) when the insecticide is applied.

When insecticides are applied with small, portable equipment, care must be taken that the correct fuel mixture is used, that the insecticide does not leak and the engine does not overheat. Further details about the use of space spray equipment can be found in publications concerning vector control.

Evaluation of Control Measures

Evaluation of emergency control measures is often done poorly or is completely ignored because of inadequate planning and lack of resources and trained staff. If an epidemic is curtailed, or fails to develop, the operation is essentially considered to have been successful.

This practice should not be overly criticized; emergency operations should not be delayed because there has been no opportunity to evaluate them. However, it is always advisable to evaluate control measures, since proper evaluation can save valuable time and money during all stages of emergency operations, and can contribute to the guidelines to be used in future emergencies.

Evaluating entomological control measures provides important information that can be used as the basis for deciding when and in what exact areas insecticides should be applied. It also allows the effectiveness of the insecticides, and of the overall program to be assessed. Evaluation of the procedures used and of the quality and amount of work performed will point to failures and ways in which failures can be remedied.

The same information is needed about the success of control measures taken after natural disasters and other emergencies. Thus, if procedures have already been adopted for evaluating existent vector control programs in the area, their use can be extended to the evaluation of the entomological control measures taken during the emergency.

The population sampling methods that have been described above in regard to surveillance can also be used for the evaluation of chemical control measures. Larval surveys in which the House, Container and Breteau Indices are used, may yield indication of pretreatment and posttreatment changes in the size of larval populations. These surveys are especially helpful if larvicides have been applied. To some degree they can also be used to determine the extent of public acceptance of the treatment, if the presence or absence of sand granules or miniquets is noted. However, in evaluating emergency adulticidal action, larval surveys will show little or no immediate response.

Space spray operations by either ultra-low volume applications or thermal fogs should lower the adult population immediately. Pretreatment and posttreatment comparisons of adult resting or landing collections will show not only the immediate effect of treatment on the population at the end of twenty-four hours; if comparison is made after treatment at two or three day intervals, the results can be used to schedule additional insecticide applications. Similar timed collections made in an untreated area will show the effect of climatic changes upon changes in population densities, or other unrelated fluctuations which may be taking place simultaneously. If there is a trained technician available, it is worthwhile, but not essential, that the technician dissect the organisms to obtain pretreatment and posttreatment parous rates.

Ovitrap can also reflect immediate changes in the adult female population. If sufficient numbers are used, they may reveal population recovery and indicate where there have been misses or weakness in coverage.

Use of bioassays, of insectary-reared *Aedes aegypti* or other species, is a valuable method of evaluation. Wild-caught mosquitoes may be used, but if they are it will be necessary to adjust the sample size to compensate for lack of uniform age of the sample. Three- or four-day-old, blood-fed females are usually used for adult bioassays, and third or early fourth instar larvae are used for the larval bioassays. The latter are, however, of limited value for the evaluation of space spray applications.

Adult bioassays are performed by placing thirty to one hundred adults in a cage. Excellent, reusable cages can be constructed with galvanized screen wire although it is also possible to use inexpensive, disposable cages that can be made with paper cups, cardboard tubes, or wire frames covered with a fine

mesh fabric such as tulle. The cages should be placed at thirty to one hundred meter intervals across the path of an aerial swath, or at right angles to the path of ground equipment, in the direction of the spray. One hour after exposure, the cages are collected and the insects are transferred to clean holding cages. There they are given food and held for a 24 hr. mortality count. It is usually true that the closer the source of spray, the higher is the mortality rate. Mortality rates should be plotted against site of the cage. The results should give indirect indication of mortality rates of the natural populations, and of swath width, unsatisfactory coverage and other breakdowns in application.

Immediately following a natural disaster, or during a vector-borne disease epidemic, the possibility of insecticide resistance is sometimes forgotten. The World Health Organization has kits for testing the susceptibility of adult and larval mosquitoes to insecticides. If these kits are not available, field bioassays of various available insecticides can be performed. In the Americas, there is resistance of *Aedes aegypti* to organochlorine insecticides, and in certain areas tolerance to some of the organophosphate insecticides may exist. Even where there are no routine vector control programs, the use of agricultural and household pesticides may increase the potential for resistance development.

When ultra-low volume equipment is used, it may be necessary to calibrate dosage and determine the droplet size. The technical brochures provided by the equipment or insecticide supplier should contain information about these procedures.

Chapter 6

Anopheline Vectors of Malaria

Malaria control or malaria eradication programs are found in most malarious countries. Depending on the state of the program, its administrative structure and function may vary. Natural disasters, such as hurricanes and floods, may affect the breeding sites of anopheline mosquitoes. In areas where malaria is endemic, the likelihood of an increase in malaria cases two or more months after the disaster must be considered and appropriate action taken.

Surveillance of Malaria

Malaria surveillance can be directed toward the detection of human cases or toward changes in the mosquito population. In malaria control programs, case detection is of greater priority.

Epidemiological Surveillance of Human Cases

Most malaria programs entail both active and passive case detection. These activities include the taking of blood slides by either voluntary collaborators or program staff members, who make house-to-house visits following established procedures, and at clinics, hospitals and health offices. The information should be studied that is yielded from the yearly and monthly blood slides made in all areas directly or indirectly influenced by the disaster.

Once the eradication program of a country is in the maintenance phase, there are certain circumstances in which there is great potential for reestablishment of transmission. The threat of transmission is posed when there are a large number of imported cases of malaria, suitable environmental conditions and a relatively high abundance of anopheline vectors.

Areas within the range of disasters of potential risk of malaria transmission can be delineated according to the above factors. Malaria surveillance should be upgraded after a disaster. If there is relocation of populations or changes in community life and activities, this may involve considerable reorganization. Voluntary collaborators should be on the lookout for a sudden rise in the number of fever cases. All government and private medical facilities should also be alerted, and activities undertaken in the field and in laboratories should be evaluated.

An alert of this type is always capable of overtaxing the capacities of laboratory facilities. When there is great concern that a malaria epidemic may occur, there should be an attempt to increase the size of laboratory staff or that of any other laboratory with qualified technicians, such as those of medical schools, hospitals and private clinics. It should be noted, however, that redirection of slides will cause additional logistical problems for the epidemiologist who is gathering statistics.

The epidemiological program may face a number of other problems. Census data and maps may be inaccurate because of the movement of families after a natural disaster. Officials in the malaria control program should establish surveillance systems in new settlements which allow them to correct such inaccuracies.

Officials of the epidemiological surveillance service should know which malaria parasites are present in a community, and should monitor any changes in prevalence. An evaluation should be made of the changes in risk, and to indicate the existence of areas or populations in which complimentary control measures are required. Control tactics encompassing chemoprophylaxis, case detection and treatment, and vector control activities should be developed. An appropriate monitoring system should exist in which staff members are alerted to necessary changes regarding the timing of their strategy. Both the stocks of antimalarial drugs and the ordering of new supplies should receive periodic review.

In the interval between the onset of disaster and the period of possible increase in malaria infections, the director of the malaria control program should ensure the complete reestablishment of the full surveillance operation, with voluntary collaborators, field staff and health services. This will entail the provisioning of adequate supplies of antimalarial drugs for both prophylaxis and case treatment.

Epidemiological and entomological vigilance should be intensified and pertinent data should be displayed on a large, schematic map which usually facilitates the assessment of areas that require priority attention. The extent

and the distribution of both confirmed and suspected cases of malaria should be shown. The major agricultural growing area, and the areas of high-risk of disease transmission should be delineated according to three factors. These are the size and distribution of vector populations, increases of larval breeding sites, and the presence of potential disease reservoirs.

The epidemiologist should meet with members of the program's vector control and entomology staff to study the increases that may have occurred in malaria infections and changes in vector population densities.

Entomological Surveillance

Entomological surveillance in malaria control programs has not historically received adequate attention. The entomological surveillance system will thus probably be less effective after a natural disaster than the epidemiological system. However, vector control personnel may have been involved in the evaluation of antivectorial measures and may have valuable information about the insecticides and the vectors. Specifically, they may know about the state of insecticide susceptibility, duration of residual effect, and spraying cycles. Concerning the vectors, they may have information about the delimitation of seasonal and geographic aspects of vector influence, the habitats and behavior of primary and secondary vectors, and the vectorial capacity of these mosquitoes.

The foundation of most malaria control programs lies in the activity of vector control personnel. Consequently, it is members of the vector control staff who will have maps, be able to provide up-to-date information about insecticide treatments, and have a thorough knowledge of the communities. They will also know the epidemiological situations (attack, consolidation, and maintenance) of various areas, and thus they make plans for emergency control accordingly.

If there are entomological and vector control personnel available in the malaria program, a postdisaster survey should be taken in the suspect endemic area. The survey should entail gathering the following information from those potential risk areas:

- (1) Location of larval site sampling stations, classified according to future productivity of vector species and plotted on contour maps
 - (2) Adult mosquito densities determined by:
 - (a) human and/or animal collections
 - (b) resting and/or pyrethrum knockdown collections
 - (c) light traps
 - (d) other methods of collection that can be undertaken if there is available staff and time and equipment.
-

- (3) Anopheline species determined to be involved in the area and the possible flight ranges from the various breeding sites
- (4) History of insecticide treatment, and the results of insecticide susceptibility tests as well as bioassays of the walls of structures that have been treated recently with insecticide.

Once these initial surveys have been completed, permanent study sites can be located in which the monitoring of larval and adult anopheline densities can be continued. Meteorological events in the areas, especially of rainfall, should be recorded. Vector densities should then be compared with changes in these events. The type of agriculture, and human and domestic animal movement into or away from the risk areas should be noted.

Night bait collection of anophelines will be necessary because of their biting habits. This will require overtime work and additional transportation costs for the entomology teams.

In the section of Chapter 5 entitled "Surveillance," a detailed discussion on larval and adult collection methods is presented. Specific points to be considered in anopheline surveys include the following facts:

- (1) Not all of the species of anopheline mosquitoes are vectors of malaria
- (2) Various anopheline species may have different host preferences
- (3) The biting times of the different anopheline species vary
- (4) Not all of the anophelines enter light traps
- (5) Some anophelines are endophilic, and some are exophilic, while others are both
- (6) Flight ranges of the various anophelines are not the same.

A comparison of the findings of geographical reconnaissance and preliminary surveys, and routine surveys in the risk area should give the entomologist information with which to assist the vector control specialists in planning control activities. The basic information to be obtained includes knowledge of the following:

- (1) The vectors that are present in the area, and their breeding sites
 - (2) The seasonal variations and relative densities of the vectors
 - (3) The vector's host preferences and feeding, flight and resting habits
 - (4) Susceptibility of vectors to insecticide
 - (5) The extent of man-host contact
 - (6) The presence or absence of active malaria transmission
-

- (7) The proper application and current residual effect of insecticides in dwellings, which may be difficult to evaluate if vector control staff members have not kept records of the previous spraying, dates and chemicals applied
- (8) Alternate insecticides that are in stock or can be ordered
- (9) The local geographical, meteorological and hydrological conditions that determine breeding season and sites.

Anopheline Control

Mason and Cavalié reported (1965) on a malaria epidemic that followed Hurricane Flora in Haiti. They observed that the majority of the population was without shelter or lived in temporary shelters with the maximum exposure to mosquitoes. They also noted an almost complete removal of insecticide coverage in existing houses, and an increase in population movement. In Hurricane David in Dominica in 1979, approximately eighty percent of the roofs were blown off the dwellings, exposing interiors to heavy rainfall. Under such circumstances, there is little likelihood that much residual insecticide will be left on the structures. Factors such as these, as well as potential changes in vector densities, must be considered when control activities are planned.

The control approach to be taken should reflect the influence of such factors as the status of the routine spraying operations, the results of wall bioassays in treated houses, the predisaster malaria situation, and mosquito breeding sites and adult population densities. Housing conditions and human population movements should also be reflected in control measures. Antimalarial drugs will undoubtedly be part of any prevention or control campaign, but only vector control measures will be discussed here.

A basic anopheline control program may consist of the following elements:

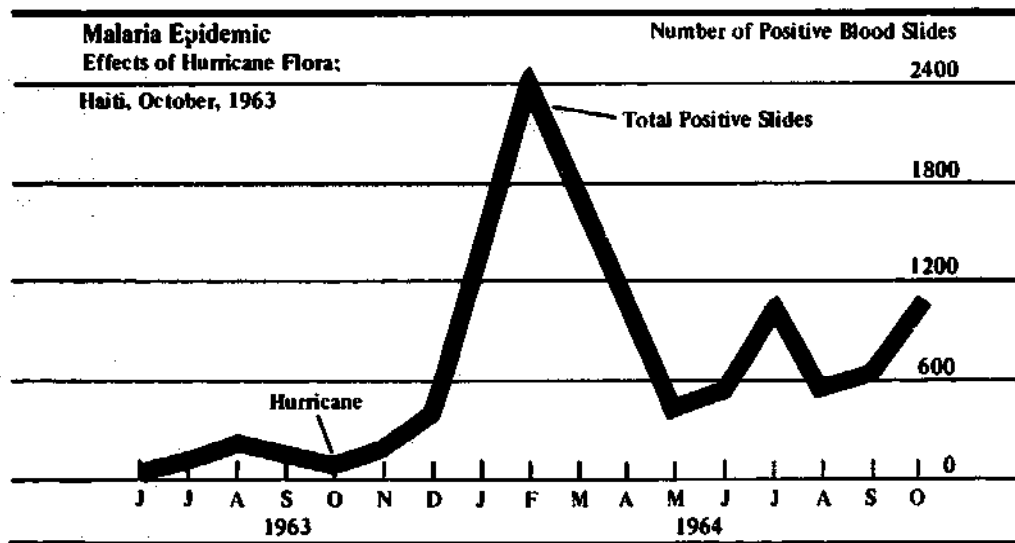
- (1) Source reduction, by filling and draining breeding areas
 - (2) Larval Control through these measures:
 - (a) Introduction of larvivorous fish
 - (b) Focal treatment of larval habitats with mosquito larvicides
 - (3) Adult Control through the following:
 - (a) Residual applications using hand compression sprayers
 - (b) Perifocal treatment in small or isolated areas with knapsack mist blowers
 - (c) Peridomestic treatment in large accessible areas with vehicle-mounted aerosol generators
 - (d) Aerial dispersal for the control of emergency outbreaks that can not be handled by ground equipment.
-

Larval Control

In malaria programs larval control measures have generally been taken secondarily to adult control measures. However, if the disaster has taken place in a country in which larval control is practiced, an attempt should be made to reinstate these measures as soon as possible. The type of larval control measures that should be taken depends upon the breeding sites of the vector involved, and requires entomological guidance.

In areas in which environmental management is used, aerial reconnaissance should provide information about the condition of drainage facilities and standing water, and engineering observations regarding remedial actions. Some work can be started, either manually or with available equipment. However, environmental management is usually slow to initiate and it is too expensive at the start to play more than a superficial role in emergencies.

Biological agents, especially larvivorous fish, have been used in routine larval control. It is possible that these agents will be destroyed or widely dispersed during the disaster, and thus be of little value in control. If these agents have been used, however, their current status should be determined. High-risk areas should be restocked as soon as possible if fish breeding programs are present outside of the disaster area.



Although infectious disease outbreaks do not usually follow upon disaster, the potential for the transmission of vector-borne disease can increase through disruption of vector control efforts in some areas. During the five month period following the hurricane that struck Haiti in 1963, seventy-five thousand cases of *falci-parum* malaria occurred.

Chemical control measures are more effective for epidemic conditions. Where larvicides have been applied routinely, their use can be continued if the biology and habitats of the vector warrant it. Insecticide susceptibility should be tested with field-collected larvae before larvicide is ordered or used.

There are various kinds of application equipment that can be used to treat water surfaces. These include hand compression sprayers, orchard and agriculture ground equipment, and aerial spray systems. A different technique and nozzle is used in larviciding with hand sprayers than in residual wall application. Products such as "Tossits," briquetts, and granules can be dispersed by hand

Besides the more routine organic chemicals, petroleum oil products, non-petroleum monolayers, and insect growth regulators can be used for larval control. Perhaps in the future, bacterial and other biological agents can also be employed.

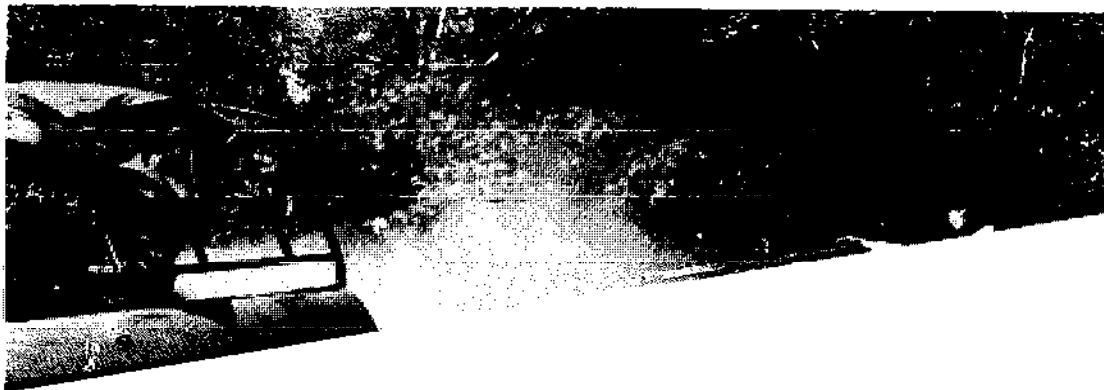
Adult Control

In emergency situations, adult control is the best approach for suppressing anopheline populations. Most malaria control programs in fact utilize adult control as the basic tool of their mosquito control effort. However, if it is to be effective, the vector must be susceptible to the insecticide used and must come into contact with it. A hand compression sprayer with an appropriate nozzle is the method of choice for residual application of insecticides on the walls of houses and on the other resting sites of anophelines.

The selection of the types of insecticide to use should depend upon entomological information such as the results of susceptibility tests and wall bioassays, and on the availability of the product. In an active malaria program, there is no reason to substitute insecticides or to change the routine approach. Spray teams should enter the area to be treated as soon as possible after a disaster, where they should treat temporary housing, and, when necessary, retreat permanent housing. They should keep abreast of the movement of people and of all new construction. Community involvement should be increased for several months following the disaster.

Wettable powder formulations are usually used in malaria programs. Emulsifiable concentrates can be used in houses with painted walls, where deposits left by wettable powders may be deemed objectionable. After natural disasters, however, the choices are quite often dictated by current availability or the speed of delivery.

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tor from the habitat of man. Whenever possible, screen windows and doors should be furnished and those individuals who are not protected should be provided mosquito nets and encouraged to use them. If this step cannot be taken, reliance must be placed upon personal prophylactic measures. When breeding places near the camp cannot be drained, they should be treated with oils or larvicides. Insect repellents, such as DEET and pyrethrum coils, can be used on either an individual or a group basis. Regular use of antimalarial drugs should be recommended in malaria endemic areas.

Health education, combined with individual and community involvement, can minimize the effect of an epidemic. Thus, it also makes the work of the vector control staff easier.

Evaluation of Control Measures

No increase of malaria infections, or the rapid, drastic reduction of cases during an emergency are true signs that control measures for malaria are effective. Current epidemiological data should, therefore, be available to guide the activities of control personnel.

Evaluation of the effectiveness of the level of entomological and vector control should take into account the results of bioassaying the walls of structures to ascertain the extent of insecticide coverage and residual activity. The number of houses sprayed, not sprayed and refusals, must also be recorded, and the current status of susceptibility of vectors to insecticides needs to be evaluated.

Chapter 7

Culex quinquefasciatus and Other Pest Mosquitoes

Culex quinquefasciatus will in most cases be considered pest mosquitoes. In some areas, however, they are vectors of St. Louis encephalitis and bancroftian filariasis. A number of other mosquitoes that are also normally considered pest mosquitoes may be vectors of arboviruses. These mosquitoes are treated superficially because of the variety of larval habitats encountered and because of their limited medical importance. In many cases, they will cause complaints, and some type of action against them may become necessary.

Surveillance

There will be little available baseline information about pest mosquito densities unless it has been collected because of a tourist industry or in a municipal mosquito control program. The pest mosquito population density immediately after a natural disaster may be low as in the case of *Aedes aegypti*. Changes in the environment which occur both during and after a disaster may, however, favor rapid population increases.

Mosquitoes that breed in certain habitats may increase in number within one month after a disaster. These habitats are salt marshes, bogs, fresh-water swamps, mangrove swamps, sewage effluents, semi-permanent ponds, woodland pools, artificial containers, ditches, irrigation wastes, water impoundments, rice fields, and natural containers such as tree holes, rock holes, and crab holes. Although problem species will differ greatly from area to area, they should not go unidentified. Surveillance, if meaningful, must include knowledge of the species and habitats of all mosquitoes encountered.

Checklists of the mosquitoes and other biting insects that have been collected in the area may exist in universities or libraries. Basic information about flight range, host preferences, life cycle, larval habitats, adult resting

places and specific control methodology, may be obtained from the literature.

Topographical maps and aerial photographs assist in locating potential problems, as they do in the case of *Aedes aegypti*. In areas where there has been some type of environmental management such as diking for purposes of mosquito control, reconnaissance flights provide valuable information about the condition of the control method. (Maps and photographs can also be used to locate sampling stations for use in evaluating population densities.) If topographical maps or photographs do not exist or do not produce the information required, taking simple photographs and making maps while in flight can help in orientation and location of breeding places. Such flights can also be of service for planning chemical control and drainage operations.

Culex quinquefasciatus breeds in highly polluted water. Rapid increases in populations might occur where pit latrines have been constructed as a temporary measure after a disaster has disrupted normal sewerage systems. Refugee camps should, therefore, be examined regarding the placement of latrines, open dumping of garbage in flooded areas, and the existence of any other standing water (especially artificial containers) that might become polluted.

Population sampling can generally be accomplished at weekly intervals in marshes, swamps and impounded water habitats. Biweekly collections of *Culex quinquefasciatus* may be necessary. It must be emphasized, however, that these mosquitoes are unlikely to be a medical problem and sampling should be considered only if staff and resources are already available. Control of most *Culex quinquefasciatus* habitats can be effected without a great amount of surveillance. Complaints from the refugee or resettlement sites may provide sufficient surveillance.

Estimates of Larval Populations

In initial surveys, the collector must assume that wherever there is standing water there are mosquito breeding sites. As the collector becomes familiar with the area, species and preferred larval habitats, the observations can be refined. Entomologists can assist in identification of the specimens.

Larvae are collected with a white enamel dipper, white enamel pans or other water containers or a siphon. Flashlights or mirrors can be used to illuminate breeding places and to locate water and evidence of breeding. Medicine droppers and other types of pipettes can be used to transfer larvae from the collecting device to vials and bottles. For convenience, dips are usually done in multiples of ten, and inspections are made either weekly or every two weeks.

Estimates of the Adult Population

Adult surveys must be designed to show a relationship between breeding sites and the human population. Changes in population densities observed through one or more collecting methods can be used to determine the need for adult control measures, their effect, the extent of the mosquito problem and the possible arboviral trouble spots. As with all surveys, it is essential to have maps of the area, well designed forms for collecting data, use of standard collecting methods and sites, and a well organized and trained staff. Under some conditions, it is possible to use the adult collections to attempt to isolate arbovirus. This should be considered only if there is an indication of Venezuelan, eastern, western, or St. Louis encephalitis or other arbovirus activity in the vicinity of the disaster. There must be a laboratory that can handle the isolation attempts, as well as the necessary field and laboratory entomological equipment, and trained staff available to carry out this type of work.

There are a number of methods that can be used to collect mosquitoes. The following is a listing of possible methods:

- (1) For landing/biting collections in which either animals or man are used:
 - (a) Determine the biting habits of the vectors
 - (b) Standardize the time of day and the location of collection, the length of collecting period, and the type of bait used
 - (c) When a vector-borne disease problem is known or the population densities are high, employ landing rates.
 - (2) For window traps (used if time and staff permit):
 - (a) Use either entry or exit traps (the latter are used in some malaria entomological evaluations)
 - (b) Employ entry traps (non-blooded mosquitoes only) for virus isolation attempts
 - (c) Operate during the night when the bait is in the shelter
 - (d) Standardize the number of collections per unit of time.
 - (3) For animal bait traps:
 - (a) Use traps of sufficient size and strength to hold the bait animal comfortably and to permit easy entry and removal
 - (b) Operate at night and standardize the time at which the bait is placed in the trap and removed (even early morning temperatures can be uncomfortable for a caged animal)
 - (c) If the specimens collected are to be used for virus isolation attempts, use traps that are designed to separate the caught mosquitoes from the bait
-

- (d) If a carbon dioxide trap is also desired, use smaller bait traps like the Lard Can Trap designed by Bellamy and Reeves (*Mosq. News* 12: 256-258).
- (4) For light traps:
 - (a) Choose from several types, the two most popular of which in the Americas are the New Jersey and the Centers for Disease Control miniature light traps, or modifications of them, and if there is no electricity, consider use of battery models
 - (b) Remember that light traps attract both males and females from considerable distances, and that collection with the CDC light trap can be enhanced with a supply of carbon dioxide or by hanging dry ice nearby
 - (c) When locating or positioning light traps, take care not to place them in competition with other light sources
 - (d) Remember that collections can be made of live mosquitoes by attaching a mesh bag, and of dead mosquitoes by attaching a killing jar; and that live collections can be used for virus work
 - (e) Run traps on a schedule and, preferably, at established sites
 - (f) Take care in handling and separating material, since many other insects are also attracted to light traps.
- (5) In regard to natural and artificial resting stations, it is useful to know that:
 - (a) Many mosquitoes (especially some species of *Anopheles* and *Culex*) seek out dark, cool humid places to rest during the day
 - (b) It may take some searching to find natural resting places for different mosquitoes; buildings, especially unscreened ones that shelter man and animals, bridges, culverts, caves, and hollow trees, may serve as resting sites; collections can be made with an aspirator
 - (c) Artificial resting boxes have been used with some success, but during emergencies that follow disasters their use might not have to be considered
 - (d) Large mechanical aspirators and vacuum devices may be used for collecting mosquitoes that are resting in vegetation.
- (6) Use of the sheet drop technique, described in Chapter 5, is questionable in disaster situations.

The interpretation of larval and adult surveys depends upon the baseline data that are available and the types of vector-borne diseases found in the

disaster stricken area. Pest mosquitoes will cause a great amount of discomfort in many postdisaster situations. However, priorities have to be weighed before funds and staff are committed to controlling them.

Culex Control

Larval Control

Environmental management is an ideal method of mosquito control. If a natural disaster highlights pest mosquitoes, long-term environmental management (i.e., filling, draining, stabilization of water, and source reduction) should be considered in the future. Immediate corrective measures, however, are most likely to take the form of a type of chemical control directed towards adults or the larvae.

In addition to the usual chemicals (i.e., organophosphorus, carbamates and chlorinated hydrocarbons) petroleum oils, nonpetroleum monolayers, synthetic pyrethroids and insect growth regulators are available as larvicides. The selection of a larvicide should depend on insecticides, the susceptibility of the target mosquito to the chemical, the effect of the larvicide on nontarget organisms, the type of habitat that is being treated, and the relative costs. To avoid the development of resistance, it is recommended that a different chemical be used for larviciding than that used for adulticiding.

Adult Control

The same general space spraying methods used for the control of *Aedes aegypti* (i.e., thermal fogging and ultra-low volume aerosol application) can be used for most pest mosquitoes. Aerial applications of pest mosquito insecticides are used effectively for the abatement of mosquitoes in the United States of America. This type of control should probably not be considered for pest mosquitoes, however, unless aircraft used for public health are readily available. Exceptions are in areas with arboviral diseases in which pest mosquitoes have been incriminated as vectors, or in situations in which malaria vectors and pest mosquitoes are both increasing in number.

Individuals should be encouraged to use repellents, to burn pyrethrin coils at night and to sleep under mosquito nets. Small aerosol dispensers can be used in local situations, including refugee camp sleeping areas.

Chapter 8

Flies, Rodents and Other Vectors

Synanthropic Fly Problems

Synanthropic flies are those that enter and adapt to the human ecological community. The unsanitary habits of man cause this relationship to develop. Increases in the fly populations may be expected after natural disasters, because of breakdown of sanitary services. The presence of synanthropic flies has potential epidemiological and hygienic implications, and the flies are an annoyance interfering with human comfort. The house fly, *Musca domestica*, is both a filth feeder and breeder, and health problems can occur when it comes into contact with human food and drink. The contamination of food and drink by pathogens can take place mechanically, through its legs, body, proboscis and wings.

The pathogens can also be defecated or regurgitated. Flies have been incriminated in the transmission of many of the enteric diseases of man, including dysenteries, cholera and typhoid fever. Yaws, conjunctivitis, enteroviral infections, and intestinal parasites may be transmitted by different species of flies.

Female house flies oviposit in a number of habitats, especially in garbage and animal wastes. When the average outside temperature is between 25° and 30°C, the life cycle of the fly from egg to adult, is approximately one to two weeks.

Surveillance and Survey Methods

Active fly control is not often included in most health programs. The first indication of a fly problem may be that of complaints from people living in refugee areas or who return to their homes in the disaster areas.

There are a number of fly traps, such as sticky paper, that can be used to appraise population densities. Not all synanthropic flies, however, enter houses

and thus, markets, garbage areas, and even outdoor resting places have to be included as areas of appraisal. The easiest way of performing a survey is to count flies as they rest on refuse, vegetation, the walls of buildings and other resting places. Comparable information can be obtained with fly grills. (*Ann. Rev. Ent. l.*: 323-346).

There are a number of other diseases of which rodents may be reservoirs. These include rabies, rat bite fever, rickettsial pox, spotted fevers, and rodent associated viral hemorrhagic fevers. For any rodent-borne disease problem, it is essential to determine if the disease is or recently has been in the disaster area. Since many of these diseases are associated with ectoparasites of the reservoir, it is important to know the natural histories of the diseases and to implement an appropriate control program against rodents and their ectoparasites.

Control and Evaluation

Prevention is recommended over control. High priority should be placed on sanitary services in refugee camps because of crowding and other unhealthy conditions. Sanitary services should also be restored to communities as soon as it is possible. Dead animals should be immediately cremated or buried, pit latrines should be made flyproof, and the rooms in refugee buildings, particularly kitchens and eating places, should be screened.

The public should receive health education about ways to prevent fly breeding. Other activities to recommend include burying garbage when sanitary services are not available, and using fabric curtains at doors and windows to limit fly entry. When available, the use of sticky tapes and household aerosol sprays inside of buildings may help to reduce fly numbers.

Chemical control of filth flies over a long period of time is usually not recommended because their resistance to insecticides develops rapidly and is already widespread. During disasters, however, it may be necessary. Residual spraying of indoor resting places may be required and, if available, sugar and syrup baits with insecticides can be utilized once the sanitary program is well underway. Use of diesel oil in pit latrines is a quite effective control measure. Space spraying resting and breeding places with available insecticides (those used for malaria and anti *Aedes aegypti* programs) can help to reduce fly numbers.

Evaluation may be largely based on direct observation. If an insecticide is not causing an appropriate level of mortality, an alternative should be used. Walking through an area, especially around pit latrines, food preparation

areas and garbage collection sites, provides a means of visually assessing the reduction of the population. In control operations, it should be taken into account that flies can migrate up to four miles to new food attractants or to breeding areas. More accurate information may be obtained through the use of standardized fly grill surveys.

Rodent Problems

The environment of the rodent undergoes the same change as that of man after a natural disaster since their harborage and food sources are also damaged or destroyed. The rodent will consequently be in competition with man for whatever food and shelter remain. Commensal rodents and other animals are more visible to man following a disaster and may migrate into his environment. Unfortunately, what the rodent does not directly consume, it may damage and contaminate.

The rodent species that are of concern are the Norway or brown rat (*Rattus norvegicus* Berk), the roof rat (*Rattus rattus* L.), also known as the ship or black rat, and the house mouse (*Mus musculus* L.). Rodents have been involved in transmission of a number of infectious diseases to man. The most important ones are:

- (1) Plague, which is endemic to Brazil, Bolivia, Ecuador, Peru and Western United States, frequently involves rodents other than domestic rats
- (2) Murine typhus, cases of which occur throughout the world in areas of warmer climates where commensal rats, especially *R. norvegicus*, are the chief reservoirs
- (3) Leptospirosis, with a worldwide distribution, is maintained in reservoirs of commensal rodents, dogs, pigs and cattle
- (4) Salmonellosis, which occurs when commensal rodents are infected with *Salmonella* and the infection is transmitted to man in contaminated foods and liquids, spread by infected fecal droppings or by urine; the house mouse probably plays a greater role than rats in the transmission of food-borne illnesses.

The economic and nutritional importance of loss of foodstuffs because of rodent contamination must also be considered. Damages and losses caused by rodents are substantial, and during natural disasters this extra burden can be serious.

In many cases, since rodent control is not the direct responsibility of the central government, it may be difficult to obtain predisaster information. Ro-

dent surveys and control work are usually undertaken by the port authority in seaports, by the local governments of cities, or by the Ministry of Agriculture. These agencies may be sources of background information, supplies and materials for rodent control, and expertise regarding surveys and the organization of control activities. In the private sector, pest control operators may be an excellent source of assistance and relevant information.

Rodent Surveys

Information about rodents can be collected in interviews with people who live in temporary housing and refugee camps after natural disasters. The location and relative density of rodents sighted should be determined at this time.

If an individual familiar with the signs and traces of rats and mice can be located, a survey of large areas can be performed fairly rapidly. The major signs are fecal droppings, rodent runways, rodent footprints or tail marks in dust and tracking powders, gnaw marks of rats and mice, burrows, and nests. Rodent odors, especially of house mice, and urine stains that can be seen under ultra-violet light are also indicative.

Sightings increase when the cover of the rodents is disturbed. After natural disasters it is possible to obtain information through daylight surveys in affected residential areas and near rescue centers. Additional information can be obtained during dusk and early evening surveys. These may be undertaken at random, or through the selection of potential trouble spots. Strong flashlights can be used to search in such places as under buildings, and in refuse disposal areas. Maps are essential for this type of work and if they are not available, sketch maps should be made by the workers. Record should be kept of potential habitats, such as temporary refuse dumping areas and harborage, and of the number of sightings.

A more detailed survey can be accomplished when pest control operators, biologists or personnel from a rodent control program are available. Forms should be reproduced for recording information in such surveys as: the location of the survey, the type of premise, the condition of the structure, the construction materials, the number of occupants, and the presence or absence of food, water, harborage, rodent signs and traces.

Some surveyors use traps to assess the density and determine species of rodents in an area. Live traps can be used when available; otherwise, snap traps serve the purpose. If food markets or hardware stores are still standing after a disaster, snap traps can usually be purchased locally. Care should be taken not to use large numbers of snap traps if a rodent associated disease exists in which an ectoparasite is a vector.

Control

The World Health Organization document (WHO/VBC/79.726) should be consulted for the selection of rodenticides for control purposes. There are two general types of rodenticides in use. The first is the *chronic type*, a multiple dose, slow-acting compound. The second type is the *acute*, or single dose, quick-acting compound. In general control operations, the rodenticide of choice is considered to be a slow-acting anticoagulant poison. Many acute rodenticides are toxic to man and other animals. Thus, in a disrupted environment, such as that which follows a natural disaster, extreme care should be taken in using acute rodenticides. They should be used only in extreme emergencies and by well-trained control operators. Red squill is an exception that can be used against *R. norvegicus*, but it is not as effective against *R. rattus*. Anticoagulant rodenticides such as diphacinone, difenacoum, brodifacoum or chlorophacinone are available in a number of areas and have been used in emergency rodent control. The immediate needs of the control program should be determined with survey information or through estimates of experts. Locally available supplies of rodenticides should be located, and if inadequate, they should be supplemented immediately.

Rodenticides either come as preprepared bait or as concentrate. The concentrates might prove less expensive to order, but in emergencies either formulation is acceptable. In preparing food baits, it is necessary to know the rodents' food preferences. Contrary to popular belief, rats and mice prefer fresh, palatable food. Food dyes and other coloring materials that do not affect the flavor of the bait can be used as a warning to humans. Great care should be taken in mixing baits, especially those in which acute rodenticides are used. It is best to have a single individual responsible for mixing and/or packaging the bait.

Control operations should be based on the findings of the rodent surveys. Members of field teams need to be trained in placement of the bait and in public relations. Control personnel must be careful to develop positive working arrangements with the populace after a natural disaster. They should carry identification; and they should be trained well enough to understand what they are doing and why, and to communicate this information to the people.

Bait must not be haphazardly placed. Care must be taken to put the bait where the rodent will find it, but where children and other animals cannot. When the supply of rodenticides is inadequate, only the more hazardous areas should be treated. These areas include rescue centers, refugee camps, food warehouses, markets, ports and hospitals.

In areas of potential outbreaks of rodent-borne diseases where rodent control is necessary, special consideration should be paid to controlling ectoparasites. Before a trapping program is underway, rodent runs must be dusted with DDT, carbaryl, diazinon, pirimiphos-methyl or some other approved insecticide powder. Special care should be taken in handling and disposing of rodents in these areas.

The use of rodenticides is only a small part of a well-organized rodent control program. During a natural disaster, however, it is of greater importance than during routine operations. Sanitation is another important aspect, and it must be remembered that by creating harborage, the accumulation of garbage and debris encourages the establishment of rodent populations. Refuse and debris should be thoroughly incinerated when sanitary landfills are unavailable, because on-site burning is of limited value.

No control program can be successful without the cooperation of the people it serves. Such programs should always incorporate sanitary education, and other campaigns to enlist the help of community groups and individuals.

Other Vector Problems

Lice, fleas, mites, ticks and other arthropods may produce serious problems following natural disasters, (see Annex III). The lice of medical importance belong to the order Anoplura, or sucking lice. The important species are the crab louse, *Pthirus pubis*, the head louse, *Pediculus capitis*, and the body louse, *Pediculus humanus*. Of these, *Pediculus humanus* is the only species that is an important vector. It is the only proven vector of two diseases, louse-borne (epidemic) typhus and epidemic relapsing fever, a spirochete disease. *Pediculus humanus* and other lice can also cause a great deal of discomfort through their bites.

Surveys of human lice, with a reasonable population sample, should be conducted in order to determine the extent of the problem and the number of individuals who require treatment, and to determine the effectiveness of the control program. A louse survey involves searching for the insects and their eggs, or nits. Body lice are found on shirt collars, the waistband, pockets and seams of trousers, and the seams of underwear. Head lice are normally found in the hair of the head, particularly around the ears and nape of the neck. The nits of head lice found within 7 mm of the scalp may be considered viable. Crab lice are usually found in the pubic and perianal areas of the body.

There must be a quick reaction to a serious increase in body louse infestations, with the threat of an epidemic outbreak of disease. In an emergency, the

method of choice is that of mass delousing of the population with insecticide dust delivered by a compressed air duster. Use of cans with holes punched in one end will also suffice. Since there is widespread resistance to DDT, the dusting powders of choice include temephos (Abate), malathion, or gamma HCH (lindane). If time permits, the effectiveness of various pesticides should be assessed with the World Health Organization's insecticide susceptibility test. In emergency camps, clothing fumigants such as HCN, methyl bromide or ethyl formate can be used if the fumigation is supervised by properly trained personnel. Mass laundering of clothing is effective *only* if a water temperature of 52°C or more can be maintained. It is necessary to alert the population through public education to the dangers of louse-borne diseases and the need for mass delousing.

Head lice are not important as disease vectors, so that mass treatment may only be necessary when the prevalence is extremely high. Lotions or shampoos of malathion, pyrethrins or gamma HCH provide effective treatment. When school children are infested, treating of all family members is recommended for successfully controlling infestation. Crab lice that are not disease vectors, may be treated on an individual basis using shampoo, lotion or creme formulations of malathion gamma HCH, or pyrethrins.

Fleas belong to the order Siphonaptera. In the adult stage, all known species are obligate parasites. A number of these feed on the blood of man and his domestic animals. The most important diseases transmitted by fleas are plague and murine (endemic) typhus. Both of these diseases have host reservoirs so that attempts to eliminate the vectors should be coordinated with rodent control programs. Fleas can be collected by hand from the bodies of infested persons or animals. They can also be removed by combing small wild animal hosts, or trapped alive and anesthetized or killed. If a plague outbreak is imminent, rodent runs and burrows should be dusted and bait boxes should be rinsed with carbaryl or diazinon dust. The mass rodent control should begin only after flea populations have been eliminated, so that newly emerged fleas, deprived of their normal hosts, will not seek humans.

Mites are small, sometimes microscopic organisms that belong to the class Arachnida. Although they transmit diseases such as scrub typhus and Q fever, in times of natural disasters the disease is not an important factor. The annoyance created by itching and dermatitis can, however, be important. When people are crowded and mammals and birds share the same conditions with man, these animal ectoparasites may flow over to man. Sudden epidemics of the "itch" may thus occur in refugee or temporary camps. An attempt should be made to find the cause of the problem. Ointments exist which can be used

to treat individual cases, but the best method of solving the problem is to improve sanitary habits and remove the animal source.

The mite, *Sarcoptes scabiei*, causes an infectious disease of the skin called scabies. In scabies, the penetration of the mite can be seen in visible papules or vesicles, or tiny linear burrows which contain the mites and their eggs. Scabies may be widespread during disasters. This is particularly true in developing countries. The disease is transmitted through prolonged intimate contact with scabietic skin, especially during sexual intercourse. Treatment on a coordinated mass basis involves the use of gamma HCH, crotamiton (Eurax), precipitated sulfur in petrolatum, or an emulsion of benzyl benzoate. A second course of treatment is necessary within seven to ten days. Case finding efforts should be extended to the screening of whole families, and soap and facilities for mass bathing and laundering should also be made available.

Ticks belong to the order Acarina. Ticks are vectors of Rocky Mountain Spotted Fever, Colorado Tick Fever, Q fever, tick-borne relapsing fever and several other diseases. Certain species also cause tick paralysis. Tick surveys involve either collecting specimens from wild animal hosts, or using a tick drag. A tick drag is a piece of white flannel which is slowly pulled over the vegetation along trails and road ways for a specific distance, and is then examined. A tick problem can be reduced by clearing the vegetation fifty to one hundred feet around a refugee camp. In chemical control, an area is treated with an insecticide such as chlorpyrifos or tetrachlorvinphos.

Ants, spiders and scorpions may cause problems, especially during flooding. Since these arthropods seek high ground, they often invade houses and other shelters. Their bites can be painful; some produce intense suffering for which therapy must be considered. Health education may help to alert people of this danger. Through such efforts people should be asked to shake out clothing, check shoes before dressing and turn back bedding before retiring. Removal of debris and improvement of all general sanitation can also be of help. Insecticides can be used, especially in temporary housing, to limit the problem. Severe infestations of bedbugs may also occur under crowded conditions. Bedbugs can be easily eliminated by spraying malathion in infested areas with a hand compressed air sprayer.

Poisonous snakes seek high ground during flooding and may enter houses. The chance that they will come into contact with man is therefore increased. Occupied areas should be cleaned of debris and grass should be kept as short as possible. Universal antivenin should be available for members of the staff who clear debris, for vector control field staff, and at temporary housing camps.

Part III

Consultants

Chapter 9

The Role of Consultants in Vector Control

Frequently, entomological and vector control consultants or teams of multi-disciplinary control personnel are needed in the period following a natural disaster. The composition of such teams will depend upon the nature of the disaster and the needs of the country. In general, the team may include an entomologist, a vector control specialist, a rodent control specialist and a sanitarian. If the country has a serious malaria problem, a malariologist should be added to the team. Any individual or team should collaborate with members of epidemiological teams and existing medical and vector control staffs.

Perhaps also needed are personnel who have had practical experience and training in the assembly, calibration, operation and maintenance of vector control equipment.

The Pan American Health Organization maintains a list of experts in these fields, some of whom have had experience as consultants during natural disasters. The Organization also has a procurement unit that is experienced in handling orders for equipment and supplies, and the unit is available to assist governments in emergency situations.

Recruitment

The Pan American Health Organization and cooperating international and bilateral agencies which provide assistance to other nations have developed a system for rapidly recruiting consultants to disaster relief efforts in cooperation with other international and bilateral aid agencies. Any country that needs this type of technical collaboration should determine the exact consultant requirements such as entomologist, technical officer, sanitarian, or malariologist, and express this need to the PAHO Country Representative so that prompt action can be taken.

Briefing and Equipment

Consultants should be briefed both before and after arrival to the requesting country. The Pan American Health Organization should furnish the consultant the following information prior to departure:

- (1) The general objectives of the visit
 - (2) The expected duration of the visit
 - (3) Names of contacts, especially of the officers in positions of responsibility and, whenever possible, names of entomologists, vector control specialists, civilian and military public health officials, and other potential sources of assistance within the country
 - (4) The status of the disaster and its relation to potential problems
 - (5) The types of supplies and equipment that the consultant should take (beyond those listed in Annex II)
 - (6) A list of individuals who will supply logistic requirements, such as food, transportation, shelter and communication support
 - (7) A profile of the country containing information about geographic, climatic and demographic features, political and socioeconomic conditions, past communicable disease history and the public health infrastructure
 - (8) Current information concerning the following:
 - (a) The vector control staff
 - (b) Vector control equipment
 - (c) Insecticides and rodenticides
 - (d) Transportation and communication systems
 - (9) Information for purposes of communication, such as:
 - (a) The address, telephone, cable and telex number of the Pan American Health Organization office
 - (b) Names and addresses of hotels, especially if the consultant is to reside in an area that is not near an office of the Pan American Health Organization
 - (c) United Nations Development Program, other United Nations, and international or national agencies which operate in the country.
 - (10) Information regarding passport and visa requirements, appropriate currency, airline ticket, and excess accompanied luggage allowance.
-

The consultant can supplement this by reviewing information about diseases, vectors and geographical conditions of the country. Possible sources of such information are libraries, newspapers, United Nations country background reports, universities, area handbooks, other consultants' reports, and individuals with past experience of the conditions in the country. Local amateur radio operators who have contacts in the country can provide valuable additional information.

The Pan American Health Organization, other international agencies and bilateral aid programs handle arrangements for travel and local contacts. They will inform their officials within the country about the consultant's arrival and request arrangements be made to meet with the appropriate national authorities.

The local contact in the Pan American Health Organization should brief the consultant about the following:

- (1) Government contacts who work in the areas of public health, agriculture, defense, and natural resources
- (2) The current status of disaster and vector or rodent problems
- (3) Past reports about vector and rodent-borne diseases, in the possession of the Pan American Health Organization or the national government
- (4) Other assistance being provided by international agencies and organizations
- (5) Nongovernmental contacts and/or other sources of information, including local pest control firms and aerial spray operators
- (6) Any recent changes in government plans
- (7) The political or economic implications of the disaster
- (8) Road conditions and the availability of ground transportation for field work
- (9) A sample of press reports about disaster conditions.

Activities of Consultant upon Arrival

We recommended that the consultant initially contact the international or bilateral agency that arranged the visit. The emergency or disaster committee with a vector control subcommittee if one exists, should then be contacted. Whatever the points of technical contact may be, it is the consultant's responsibility to obtain a clear concept of what is required to identify his designated counterpart in the government and to maintain close communication with appropriate authorities.

In most cases, the consultant will be asked to help the government assess the problem, outline control procedures and train personnel. The initial assessment may be difficult because of problems in transportation and communication. Maps and graphs prepared by the government will provide some information. However, there will be areas from which little or no information is available, and there will have to be adjustments to insufficiency of the information. There may be inventories of vector control equipment and supplies. These should be inspected as soon as possible.

Evaluation of information gathered in an early reconnaissance of the distribution, densities and stages of development of vector species is very useful. The consultant should be provided ground transportation for surveillance purposes and, if possible, the assigned vehicle should have four-wheel drive. In addition, information obtained in aerial reconnaissance can quickly provide a comprehensive overview of the areas and can give indication of possible methods of attack.

Outlining control procedures is often a difficult task. The effects of a given disaster may warrant the use of new technology to rapidly control vectors. Not all modern technology, however, is appropriate for use under all circumstances. A country may be aware of the existence of certain new types of equipment, insecticides and technology, and will seek to find out if they should be used. Sophisticated equipment may be used for the short-term relief from vector related problems. However, usual vector control methods, directed toward the larvae or the resting adults, may prove to be more effective and less expensive. Equipment that rusts on shelves kills few mosquitoes.

Recommendations and Reports

Recommendations should be practical and directed toward that which the local government actually can accomplish in vector control. However, recommendations can also assist governments in obtaining long-term goals that are only secondarily related to the natural disaster. It is worthwhile, therefore, to discuss all recommendations with members of international agencies and the government before writing them.

Reports should contain definitions of the potential for vector related problems and the current and future implications of the availability of manpower and other resources. Ongoing evaluation of the situation, as well as of training programs, is important because the primary concern in the report is that of the probability of the occurrence of future problems and future consequences. Actions that need to be undertaken at different points in time, or because the po-

tential of vector related diseases is altered, should be clearly specified. Also to be included in the report are alternative ways to respond to problems that develop in regard to staff or equipment.

An outline of ways to implement and evaluate control measures should be presented in the report, and actions to be undertaken in the event that epidemic occurs should be suggested. A discussion of logistics of control (including work schedules, geographical areas to be covered and ways to implement control of diseases that may contribute to epidemics) should be included in the report. The report should also contain an enumeration of methods of supervising the staff and a list of supplies and equipment that are needed to augment current stocks.

The report and recommendations can provide guidelines when such are lacking, and they may also be used for educational purposes. It should be noted, however, that because of the existence of divergent opinions an entire program is rarely accepted and implemented unchanged.

Follow-up

Consultants, remembering that it is the prerogative of the country to make final decisions, nevertheless, often outline actions to be taken in the future. To assist the government, the consultant should do the following:

- (1) Be certain that everyone is briefed and that the report and recommendations are discussed before they are formally presented
- (2) Inform the international organizations and country representatives of the recommendations and discuss the possibility of the organization's involvement
- (3) Ensure that the personnel who are actually entrusted with the work, as well as the administrators, understand what they are doing and why
- (4) Brief (by letter, telephone or in person) the technical staff of the international organization about the situation and the reasons for the recommendations.

Too often, at the departure gate, consultants forget the country and its problems. In the age of instant photocopies, sending occasional reprints of scientific reports, or a personal letter is an easy method to bridge gaps that international organizations find impossible. In many instances, such little extra effort can make the difference between the success or failure of the country to implement recommendations.

Part IV

Annexes

Annex I

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Annex II

Suggested Vector Surveillance Equipment and Supplies

Collecting bag
Mouth or battery powered aspirators
Flashlight and spare batteries
Memo pad
Pencil
White enameled dipper
Labels
Collecting vials
Bulb syringe or medicine dropper
Mirror

Collecting forms
Tea strainer
Grease pencil
Sweep net
Tweezers
Keys and other references
CDC light traps (optional)
Aedes aegypti ovitraps (optional)
Fly grill

Suggested Rodent Surveillance Equipment and Supplies

Teaching aids
Plastic bags
Plastic cups
Rubber bands
Scissors
Snap traps
Live traps
Gloves
Flashlights and batteries

Transfer bags
Vials
Alcohol
Forceps
Insecticide dusting pan
Formaldehyde
Acute rodenticides
Anticoagulant rodenticides

Annex III

Pesticides and Applications for the Chemical Control of Vectors, Rodents and Pests*

Type of Application	Pesticide and Application		Remarks
Ants; General			
Residual indoors	propoxur	1.0%	See control recommendation for cockroaches.
	diazinon	0.1%	
	bendiocarb	0.25%	
Bed Bugs <i>cimex</i> sp.			
Rooms, beds or furniture (also chicken nests for source)	malathion	1.0%	Apply lightly to mattress surfaces and more heavily to bed frame. Allow to dry before using. Never apply to children's crib.
	ronnel	1.0% E	
	dichlorvos	0.5% E	
	diazinon	0.5% E	
Cockroaches			
Enclosed spaces as kitchens, pantries or storerooms	1. Residual sprays in oil solutions or emulsion concentrates		Apply to hiding places and runways; use a spray and not a mist. Pay attention to warm humid places. Do not treat where children are likely to contact surfaces. Pyrethrins have been used as a ULV at 3-5% in unoccupied areas.
	a. propoxur	1.0%	
	b. chlorpyrifos	0.5%	
	c. bendiocarb	0.25-0.5%	
	d. diazinon	0.5%	
	e. dichlorvos	0.5%	
	f. malathion	5.0%	
	g. ronnel	2.0%	
	2. Powders in inert dusts		
	a. boric acid	90-99%	
	b. silica aerogel	100%	
	c. diazinon	2.0-5.0%	
	d. malathion	4.0-5.0%	
3. Baits			
a. chlorpyrifos	0.5%		
b. propoxur	2.0%		

Type of Application	Pesticide and Application	Remarks		
Fleas				
1. Rooms	1. Solutions in kerosene, fuel oil or in emulsion concentrates	Spray floor and baseboards and walls to a height of 10 cm.		
	a. bendiocarb		0.25%	
	b. malathion		2.0%	
	c. ronnel		1.0%	
	d. diazinon		1.0%	
	e. lindane	1.0%		
	2. Powders in inert dusts		Avoid inhalation and contamination of food.	
		a. diazinon		2.0%
		b. malathion		4.0-5.0%
		c. carbaryl		5.0%
d. lindane	1.0%			
3. DDT		10.0%		
2. Animals	1. Powders of inert dusts	Apply dust to domestic animals with small duster. Do not apply DDT, or lindane to cats or puppies.		
	a. malathion		4.0%	
	b. rotenone		1.0%	
	c. pyrethrins		0.2% plus 2.0% synergist	
	d. carbaryl		5.0%	
	e. lindane		1.0%	
	f. DDT		5.0%	
Filth Flies, adults				
1. Enclosed spaces, e.g. houses and barns	1. Space sprays or aerosols in oil solutions or emulsion concentrates (<i>Spray into air for 4 sec/10m³ when using aerosol bombs</i>):	Space sprays have no long-lasting effects and must be applied frequently. Avoid contamination of food or food processing equipment. Treat garbage, refuse, manure and other fly breeding sites. Can be used also in milk-rooms, restaurants and food stores.		
	a. synergized pyrethrins		0.1%	
	b. dichlorvos		0.5%	
	c. ronnel		2%	
	d. malathion		5%	
	2. Residual contact sprays in oil solutions, emulsion concentrates or wettable powders (<i>Apply 1% solutions at 10-20 1/100m² and 5% solutions at 2-4 1/100m² to give dosages of 1-2 g/m².</i>)			
	a. bromophos		1-5%	
	b. ronnel		1-5%	
	c. fenitrothion		1-5%	
	d. iodfenphos		1-5%	
	e. trichlorfon		1-5%	
	f. diazinon		1-2%	
	(<i>Apply at 4/100m² to give dosages of 0.4 or 0.8 g/m².</i>)			
			Same as above.	

Type of Application	Pesticide and Application	Remarks
	g. dimethoate 1-2% (Apply 8 l/100m ² to give dosages of 0.8 or 1.6 g/m ² .)	Animals must be removed. Not to be used in milk-rooms.
	h. malathion 5% (Apply 2-4 l/100m ² to give dosages of 1 or 2 g/m ² .)	Only premium grade malathion can be used in milk-rooms and food processing plants.
	i. naled 1% (Apply at 4-8 l/100m ² to give dosages of 0.4-0.8 g/m ² .)	Not to be used in milk-rooms. At 0.25% strength can be applied to chicken roosts, nests, etc. without removing the birds.
	3. Baits containing insecticides and sweetening agents as sugar, malt or molasses. Dry baits contain 1-2% and wet baits 0.1-0.2% of insecticide (Apply 60-120g/100m ² of dry bait or sprinkle the liquid bait at the rate of 4 l/100m ²):	Fly baits should not be used inside dwellings. Care should be taken that they are not placed where children or domestic animals can easily come into contact with them.
	a. diazinon b. dichlorvos c. dimethoate d. ronnel e. malathion f. naled	
2. Outdoor space-treatment	Emulsion or fuel oil formulations are applied at the following dosages: (g/ha) a. diazinon 336 b. dichlorvos 336 c. dimethoate 224 d. ronnel 448 e. fenthion 448 f. malathion 672 g. naled 224	The listed organophosphorus compounds used as emulsion or fuel oil formulations are applied at rates of 24-48 l/km to obtain the required dosage. Also, ULV applications from the ground, with bioresmethrin at 10g/ha have been found effective.
3. Aircraft	Aerosols: Resmethrin, bioresmethrin or d-phenothrin 2% + 98% Freon 11 + Freon 12 (1:1) as propellant. (Spray into air from aerosol canister for 10 sec/100m ³ .)	Approximate cabin volumes of aircraft are: Boeing 747: 2800m ³ : 3800m ³ Boeing 707: 800m ³ DC-9: 345m ³ DC-8: 800m ³

Type of Application	Pesticide and Application	Remarks										
Fly larvae												
1. Outdoors by spraying manure and refuse, human-excrement	<p>Sprays applied as emulsions concentrate or wettable powders. (<i>Thoroughly spray decaying vegetation, manure and refuse at 28-56 l/100m². Pay particular attention to animal manure, privies and garbage. In addition to the insecticides listed, ronnel, fenitrothion, fenthion and trichlorfon can be applied as finished sprays at concentrations from 0.25-2.5%.</i>)</p> <table border="0"> <tr> <td>a. diazinon</td> <td>1%</td> </tr> <tr> <td>b. dimethoate</td> <td>1%</td> </tr> <tr> <td>c. malathion</td> <td>1-2%</td> </tr> <tr> <td>d. dichlorvos</td> <td>0.5%</td> </tr> <tr> <td>e. ronnel</td> <td>1%</td> </tr> </table>	a. diazinon	1%	b. dimethoate	1%	c. malathion	1-2%	d. dichlorvos	0.5%	e. ronnel	1%	Applications must be made once or twice each week to maintain good control.
a. diazinon	1%											
b. dimethoate	1%											
c. malathion	1-2%											
d. dichlorvos	0.5%											
e. ronnel	1%											
Lice												
1. Head	Lindane 1.0% ointment or shampoo	Keep out of eyes and mucous membranes.										
2. Body	Lindane 1% dust or shampoo	Sterilize clothing and bed clothes by laundering.										
3. Pubic	<p>Lindane 1.0% ointment or shampoo</p> <p>Benzyl benzoate emulsion 25% (Pediculosis of eyelashes may be treated with 0.25% physostigmine ophthalmic ointment twice daily or a vaseline ointment containing pyrethrins may be used.)</p>	Do not apply to eyelashes. Apply by spray or hand.										
Mites: Chiggers, etc.												
Clothing	<p>1. Mosquito repellents toxic to mites:</p> <table border="0"> <tr> <td>a. diethyltoluamide (DEET, OFF)</td> </tr> <tr> <td>b. dimethyl phthalate</td> </tr> <tr> <td>c. benzyl benzoate</td> </tr> </table>	a. diethyltoluamide (DEET, OFF)	b. dimethyl phthalate	c. benzyl benzoate	Keep out of eyes. Damages some plastics.							
a. diethyltoluamide (DEET, OFF)												
b. dimethyl phthalate												
c. benzyl benzoate												
Outdoor vegetation	<p>1. Residual as wdp or powders in inert dusts:</p> <table border="0"> <tr> <td>a. chlorpyrifos</td> </tr> <tr> <td>b. diazinon</td> </tr> <tr> <td>c. lindane</td> </tr> <tr> <td>d. chlordane</td> </tr> <tr> <td>e. toxaphene</td> </tr> </table>	a. chlorpyrifos	b. diazinon	c. lindane	d. chlordane	e. toxaphene	Spray plants thoroughly. Check label for dosage. Keep children away until spray dries.					
a. chlorpyrifos												
b. diazinon												
c. lindane												
d. chlordane												
e. toxaphene												

Type of Application	Pesticide and Application	Remarks
Scabies		
Body	1. Lindane 1.0% cream, lotion or shampoo.	Keep away from eyes and mucous membranes.
	2. Benzyl benzoate (25%).	Do not apply to head. Do not overtreat.
Mosquito adults		
1. Enclosed spaces in buildings, as barracks, rooms, barns	1. Aerosols: Pyrethrins 0.25% + piperonyl butoxide or sulfoxide 2%. (Spray into air from aerosol canister for 4 sec/100m ³ .)	
	<p>2. Space sprays</p> <ul style="list-style-type: none"> a. naled 1% b. malathion 2-5% c. resmethion 1-2% d. dichlorvos e. methoxychlor <p>3. Residual fumigant: Dichlorvos dispensers, containing 20% of toxicant are suspended in enclosed spaces at one dispenser per 14-28m³. (Spray on interior walls and ceiling of building (1 1/25m²)).</p> <p>4. Residual contact sprays in oil solutions, emulsion concentrates or wettable powders.</p> <ul style="list-style-type: none"> a. DDT 5% b. methoxychlor 5% c. lindane 0.5% d. malathion 3-5% e. fenitrothion 1-2% f. propoxur 0.5-1% g. chlorphoxim 3-5% h. pirimiphos-methyl 2-3% i. permithrin 0.5% 	
2. Aircraft	Aerosols: Resmethrin, Bioresmethrin or D-phenothrin 2%. (Spray into air from aerosol cannister for 10 sec/100m ³ .)	<p>Approximate cabin volumes of some aircraft are:</p> <p>Boeing 747: 2800m³ 3800m³</p> <p>Boeing 707: 800m³</p> <p>DC-9: 345m³</p> <p>DC-8: 800m³</p>

Type of Application	Pesticide and Application	Remarks
3. Outdoors-exterior space treatment	<p>Applications from aircraft, mistblowers or thermal aerosol machines as oil solutions or emulsion concentrates:</p> <ul style="list-style-type: none"> a. malathion 100-500 g/ha b. fenitrothion 200-400 g/ha c. fenthion 112 g/ha d. naled 56-280 g/ha e. chlorpyrifos 10-40 g/ha f. pyrethroids 	<p>These sprays usually furnish immediate but only temporary relief. High volume thermal fogging may be preferable when vegetation is dense.</p>
Mosquito larvae		
1. Potable water receptacles around houses (<i>Aedes aegypti</i>)	<p>Temephos only is currently used. In treating containers with drinking water temephos 1% sand granules are applied by a measured plastic spoon at 1 mg/l (e.g. 1 g of granules for 10 liters of the volume of container—whether full of water or not).</p>	
2. Streams, lakes, swamps, pools, ruts and non-potable water containing receptacles around houses	<p>Applications from aircraft or ground equipment as emulsions, wettable powders, solutions or granules:</p> <ul style="list-style-type: none"> a. chlorphoxim 100 g/ha b. chlorpyrifos 56-100 g/ha c. fenitrothion 100-3000 g/ha d. fenthion 22-112 g/ha e. iodfenphos 50-100 g/ha f. malathion 224-1000 g/ha g. methoprene 100-1000 g/ha h. Paris green 850-1000 g/ha i. phoxim 100 g/ha j. temephos 56-400 g/ha k. fuel oil 142-190 l/ha l. larvicidal oil 19-47 l/ha m. methoprene 	<p>Do not use insecticides on water intended for drinking by humans or animals. Use all materials with care to avoid hazards to fish and wildlife. Granular formulations are more suitable for penetrating heavy vegetative cover than solution or emulsion concentrates. Higher doses are necessary in highly polluted water and by residual and pre-hatch treatment.</p>
Scorpions and centipedes		
Rooms	<p>Residual sprays as EC, wdp or powders in inert dusts.</p> <ul style="list-style-type: none"> a. diazinon 0.5% b. bendiocarb 0.25% c. malathion 3.0% d. lindane 0.5% liquid 1.0% dust 	<p>Make spot applications such as baseboards, windows, wall cracks, openings around water pipes, underneath sinks, corners. Also can treat ground and outbuildings.</p>

Type of Application	Pesticide and Application	Remarks
Spiders		
Black widow, Brown, etc.		
Residual indoors, outbuildings, and around houses, stores, etc.	1. Residual sprays as EC or wdp. a. bendiocarb 0.25% b. chlorpyrifos 0.25-0.5% c. diazinon 0.5% d. propoxur 1.0% e. malathion 2.0% f. lindane 0.2-0.5%	Do not use as space spray. Treat as for scorpions and centipedes. Watch out for falling spiders as they sometimes bite.
Ticks (most species)		
1. Animals	1. Washes, sprays or dips as emulsions a. malathion 0.5% b. rotenone 0.05% c. lindane 0.05%	Use indicated concentrations for washes or sprays but reduce to half for dips.
2. Buildings	1. Residuals in oil solutions or E.C.: a. propoxur 1.0% b. diazinon 0.5% c. chlorpyrifos 0.5% d. bendiocarb 0.25% e. malathion 2.0% f. carbaryl 2.0% g. lindane 0.5%	Treat floors and wall cracks, between and under cushions of upholstered furniture. Keep away from children and pets until dry.
3. Outdoors vegetation	1. Residual sprays in E.C., wdp or inert dusts: a. tetrachlorvinphos b. carbaryl c. dieldrin d. chlordane e. lindane	Control where needed. Follow instructions on label.
Triatominae		
House and furniture	1. Residual wdp and E.C.: a. HCH 1.0% b. fenitrothion 2.0% c. malathion 2.0%*	Treat ceiling and walls of houses and furniture when necessary.
	*not for <i>R. prolixus</i>	

Type of Application	Pesticide and Application	Remarks	
Repellents for flies, mosquitoes, gnats, mites, black-flies, sand-flies, fleas, and ticks			
Exposed surfaces of body and clothes	1. Diethyltoluamide (OFF, DEET) (<i>Application on skin. Shake ½ teaspoonful into palm of hand; rub hands together and then apply in thin layer to face, neck, ears, hands and wrists. Do not get into eyes and mouth. On clothes, spray or apply by hands. Effective for a number of days. Best all-around repellent.</i>)	Nontoxic. Avoid eyes and mucous membranes.	
	2. Dimethylphthalate (<i>Particularly effective against Anopheles and larval mites (chiggers). Use same as above (1).</i>)	Same as above.	
	3. Indalone (<i>Same as (1) above. Best use against biting flies.</i>)	Same as above.	
	4. 2-ethyl hexanediol—1,3 (repellent 612) (<i>Same as (1) above. Particularly effective against Aedes.</i>)	Same as above.	
Rodents Domestic rats and mice			
Baits	brodifacoum (Talon) ¹	0.005% bait	Single dose anticoagulant. Effective against warfarin-resistant Norway rats. Formulated as grain-based pellets. Anticoagulants. Various brands are formulated as ready to use baits, paraffinized blocks and pellets, concentrates, and as tracking powders. Also available as liquid baits. Use both liquid and dry baits where possible. Expose liquid bait in glass or plastic chicken watering devices.
	diphacinone (Diphacin) ¹	0.005% bait	
	coumafuryl (Fumarin) ¹	0.025% bait	
	pivaldione (Pival) ¹	0.025% bait	
	warfarin	1.0% bait	
warfarin	0.025% bait		

Type of Application	Pesticide and Application	Remarks
	chlorophacinone (Rozol Hot shot) ¹	0.025% bait
	zinc phosphide	1-2% bait
		Single dose poison. Mix toxicant with fresh bait materials (corn meal, fish, meat, fruit). Do not use food attractive to children.

¹Common or generic names begin with a small letter; trade or other names are in parentheses. No discrimination against similar products is intended.

*Information from WHO publications, *Pocket Guide to Pest Management* (US Navy) and *Tropical Medicine* 5th Edition (Hunter, Swartzwelder and Clyde). Mention of specific companies or manufacturers' products does not imply that they are recommended by the Pan American Health Organization.

Annex IV

**Guide to Insecticides, Rodenticides
and Equipment**

Insecticides

Abate (temephos)

American Cyanamid Company
Berdan Avenue
Wayne, NJ 07470
Telex: 130400
Tel: (201) 831-1234

Southern Mill Creek Products
P.O. Box 1096
Tampa, FL 33601

Actellic (pirimiphos - methyl)

ICI Americas Inc.
Agricultural Chemical Division
Wilmington, DE 19897

Imperial Chemical Industries
Plant Protection Division
Fernhurst
Haslemere

Surrey, England GU27 3JE
Telex: 858270 Ic. pp Fernhurst
Tel: Haslemere (0428) 4061
Tel: Somerset Court (0428) 4061
Cable: Plantecton

Altosid (methoprene)

Zoecon Industries
975 California Avenue
Palo Alto, CA 94304
Telex: 345-550
Tel: (415) 329-1130

Baygon (propoxur)

Mobay Chemical or Chemagro Corp.
P.O. Box 4913
Howthorn Road
Kansas City, MO 64120
Tel: (816) 242-2000
Cable: KEMAGRO, Kansas City

Johnson Wax Company

1525 Howe St.
Racine, WI 53403
Telex: 264429
Tel: (414) 554-2000
Cable: JON WAX RON, Wisconsin

Baytex (fenthion)

Mobay Chemical or Chemagro Corp.
P.O. Box 4913
Howthorn Road
Kansas City, MO 64120
Tel: (816) 242-2000
Cable: KEMAGRO, Kansas City

Baythion (phoxim)

Bayer AG
Pflanzenschutz
509 Levenkusen Bayerwerk
Federal Republic of Germany
Telex: 8510881
Tel: 02172-301
Cable: BAYER

Baythion C (chlorophoxim)

See Baythion *Chlordane*
Velsicol Chemical Corporation
341 East Ohio St.
Chicago, IL 60611
Telex: 910-221-5738
Tel: (312) 670-4500

Cyanophos (Cyanox)

Sumitomo Chemical America, Inc.
345 Park Avenue
New York, NY 10022
Telex: 640249
Tel: (212) 935-3813

Cygon (dimethoate)

American Cyanamid Company
See *Abate*

Cythion (malathion)

American Cyanamid Company
See *Abate*

Diazinon

Ciba-Geigy Corporation
P.O. Box 11422
Greensboro, NC 27409
Tel: (919) 292-7100

Ciba-Geigy International AG

Postfach 4002
Basel
Telex: 62991
Tel: 061/361111

Markteshim Chem Works Ltd.

Box 60
Beer Sheva, Israel

Pennwalt Chemical Corporation

1630 East Shaw Ave.
Fresno, CA 93710

Thompson-Haywood Chemical Co.

5200 Speaker Road
Kansas City, KS 66110
Tel: (913) 321-3131

Dibrom (naled)

Chevron Chemical Com.
Ortho Division
575 Market Street
P.O. Box 3744
San Francisco, CA 94105
Tel: (Orlando, Florida)
(305) 288-0414
Tel: (San Francisco, CA)
(415) 894-7800

Dimetilan

Ciba-Geigy Ltd.
P.O. Box 11422
Greensboro, NC 27409
Tel: (919) 292-7100

Dimilin (diflubenzuron)

Thompson-Hayward Chemical Co.
5200 Speaker Road
Kansas City, KS 66110
Tel: (913) 321-3131

Dursban (chlorpyrifos)

Dow Chemical Co.
P.O. Box 1706
9008 Building
Midland, MI 48040
Tel: (517) 636-2231

Thompson-Hayward Chem Co.
5200 Speaker Road
Kansas City, KS 66110
Tel: (913) 321-3131

Fenitrothion (Sumithion)

Sumitomo Chemical America, Inc.
345 Park Avenue
New York, NY 10154
Telex: 232 489 (RCA)
Tel: (212) 935-7000

Bayer AG
Pflanzenschutz
509 Levenkusen Bayerwerk
Federal Republic of Germany
Telex: 8510881
Tel: 02172-301
Cable: BAYER

Ficam (bendiocarb)

BFC Chemicals, Inc.
4311 Lancaster Pike
P.O. Box 2867
Wilmington, DE 19805
Tel: (302) 575-7847

Fison Inc.
Ag Chemicals Div.
2 Preston Court
Bedford, MA 07130
Telex: 951-253
Tel: (617) 275-1000

Fisons Ltd.
Fison House
9 Grosvenor Street
London W1X0AH, UK
Telex: 263184
Tel: (01) 493-1611

Flit MLO

Exxon Company
P.O. Box 21801
Houston, TX 77001
Tel: (713) 656-3636

Heptachlor

Velsicol Chemical Corporation
341 East Ohio St.
Chicago, IL 60611
Telex: 910 221-5738
Tel: (312) 670-4500

Iodofenphos

Rentokil Ltd.
Export Product Division
Felcourt East Grinstead
West Sussex
England RH 19 104

Lindane

Hooker Chemical Co.
P.O. Box 344
1042-7 Iroquois Ave.
Niagara Falls, NY 14302
Telex: 91-575
Tel: (716) 278-9000

All India Medical
185 Princess Street
Mulji Jetha Bldg.
Bombay, India 400 002

Thompson-Hayward Chemical Co.
5200 Speaker Road
Kansas City, KS 66110
Tel: (913) 321-3131

Malathion

American Cyanamid Company
Berdan Avenue
Wayne, NJ 07470
Telex: 130400
Tel: (201) 831-1234

All India Medical
185 Princess Street
Mulji Jetha Bldg.
Bombay, India 400 002

Sumitomo Chemical America, Inc.
345 Park Avenue
New York, NY 10154
Telex: 232489 (RCA) SUMISHO
Tel: (212) 935-7000

Thompson-Hayward Chemical Co.
5200 Speaker Road
Kansas City, KS 66110
Tel. (913) 321-3131

MesuroI (methiocarb)
Mobay Chemical or Chemagro Corp.
P.O. Box 4913
Howthorn Road
Kansas City, MO 64120
Tel: (816) 242-2000
Cable: KEMAGRO, Kansas City

Methoxychlor
E.C. DuPont de Nemours
Chemical Dyes and Pigment Dept.
1007 Market Street
Wilmington, DE 19898

Nexion (bromophos)
Celamerck GmbH and Co.
P.O. Box 202
6507 Ingelheim am Rhein
West Germany

Permethrin
Shell International
Chemical Co. (*talcord*)
Agro-Chem. Division
Shell Center
London S.E. 17PG England
Telex: 919651
Tel: 01-934-1234
Cable: CHEMISHELL
London SE 1

Imperial Chemical Industries
Plan Protection Division
Fernhurst
Haslemere
Surrey, England GU27 3JE
Telex: 858270 Ic.pp Fernhurst
Tel: Haslemere (0428) 4061

Fairfield American Corporation
3932J Salt Road
Medina, NY 14103
Tel: (716) 798-2141

McLaughlin Gormley King and Co.
8810 10th Avenue, North
Minneapolis, MN 55427
Telex: 290-544
Tel: (612) 544-0341

Wellcome Industrial (coopex)
Ravens Lane
Berkamsted
Herts, England HP4 2DY

Cooper Pegler and Co. Ltd.
Burgess Hill
Sussex RH159LA, UK
Tel: Burgess Hill 42526
Cables: 87354 COOPEG G

d-phenothrin
McLaughlin Gormley King and Co.
(Multicide)
8810 10th Avenue, North
Minneapolis, MN 55427
Telex: 290-544
Tel: (612) 544-0341

Sumitomo Chemical America, Inc.
(Sumithrin)
345 Park Avenue
New York, NY 10154
Telex: 232489 (RCA)
Tel: (212) 935-7000

Piperonyl Butoxide

Fairfield American Corporation
3932J Salt Road
Medina, NY 14103
Tel: (716) 798-2141

McLaughlin Gormley King
and Company
8810 10th Avenue, North
Minneapolis, MN 55427
Telex: 290-544
Tel: (612) 544-0341

Pyrethrins

McLaughlin Gormley King
and Company
8810 10th Avenue, North
Minneapolis, MN 55427
Telex: 290-544
Tel: (612) 544-0341

Fairfield American Corporation
3932J Salt Road
Medina, NY 14103
Tel: (716) 798-2141

S.B. Penick and Company
1050 Wall St., West
Lyndhurst, NJ 07071
Telex: 133525
Tel: (201) 935-6600
673-1335

Prentiss Drug and Chemical
363 Seventh Avenue
New York, NY 10001

Pyrethrins (encapsulated) (sectrol)

3M Company
J.F. Piper/Industrial Tape Division
Building 220 3M Center
St. Paul, MN 55101

Resmethrin

S.B. Penick and Company (SBP-1382)
1050 Wall Street, West
Lyndhurst, NJ 07071
Telex: 133525
Tel: (201) 935-6600
673-1335

Fairfield American Corporation
(Synthrin)
3932J Salt Road
Medina, NY 14103
Tel: (716) 798-2141

Sumitomo Chemical America, Inc.
345 Park Avenue,
New York, NY 10154
Telex: 232489 (RCA)
Tel: (212) 935-7000

Rotenone

S.B. Penick and Company
1050 Wall Street, West
Lyndhurst, NJ 07071
Telex: 133525
Tel: (201) 935-6600
673-1335

Sevin (carbaryl)

Union Carbide Corporation
7825 Bay Meadow Way
Jacksonville, FL 32216
Telex: 510661 2634
Tel: (904) 731-4250

Toxaphene

BFC Chemicals Inc.
P.O. Box 2867
Wilmington, DE 19805
Tel: (302) 575-7858

Hercules Inc.
910 Market Street
Wilmington, DE 19899
Tel: (302) 575-5000

Vapona (DDVP, dichlorvos)
All India Medical
185 Princess Street
Mulji Jetha Bldg.
Bombay, India 400 002

Markteshim Chemical Works Ltd.
Box 60
Beer Sheva, Israel

Shell Chemical Company
1 Shell Plaza
P.O. Box 2463
Houston, TX 77001

Insect Repellents

Deet (diethyl toluamide)
Cutter Laboratories
2200 Powell Street
Emeryville, CA 94608

McLaughlin Gormley King Co.
8810 10th Avenue, North
Minneapolis, MN 55427
Telex: 290-544
Tel: (612) 544-0341

Hills Pet Chemicals Inc.
P.O. Box 660656
Miami Springs, FL 33166

Dibutyl phthalate
Eastman Chemical Products, Inc.
P.O. Box 431
Kingsport, TN 37664
Telex: 55-34-50
Tel: (615) 246-2111

Dimelone (dimethyl carbate)
Fairfield American Corporation
3932J Salt Road
Medina, NY 14103
Tel: (716) 798-2141

Dimethyl phthalate
Eastman Chemical Products, Inc.
P.O. Box 431
Kingsport, TN 37664
Telex: 55-34-50
Tel: (615) 240-2111

MGK 11, 326,874
McLaughlin Gormley King and Co.
8810 10th Avenue, North
Minneapolis, MN 55427
Telex: 240-544
Tel: (612) 544-0341

Tabatrex (dibutyl succinate)
Glenn Chemical Co. Inc.
4149 Milwaukee
Chicago, IL 60641

Insecticide Application Equipment

Fogger, Thermal

Burgess Vibrocrafters
RT 83
Grays Lake, IL 60030
TWA 910-651-2531
Tel: (312) 223-4821
Cable: VBE Grays Lake

Curtis Dyna-Products Corporation
(Dyna-Fog)
P.O. Box 297
Westfield, IN 46074
Tel: (317) 896-2561

**J. Hofman Overseas USA,
(Dynafoq)
P.O. Box 318
Carmel, IN 46032**

**London Fog Co.
505 Brimhall
Long Lake, MN 55356
Tel: (612) 473-5366**

**Motan GMBH
(Swingfog)
P.O. Box 1260
Max-Eyth-Weg 42
D-7972 Isny, W. Germany
Telex: 7321 524
Tel: 07562-6/6
Cable: Motan ISNY**

**Lowndes Engineering Co.
125 Blanchard St. Box 488
Valdosta, GA 31601
Telex: LECO VALD 810-786-5861
Tel: (912) 242-3361
Cable: LECO VALD**

Ultra-low volume Devices

**AFA Corp. of Florida
(Fogmaster)
14201 NW 60th Ave.
Miami Lakes, FL 33014**

**Amdreas Stojl Maschinefabrik
Postfach 1760
7050 Walblingen - Neustadt
West Germany**

**Beemer Products Company
(Ground ultra-low volume sprayers)
FT Washington, PA 19034
Tel: (215) 646-8440**

**Public Health Equipment
and Supply Co.
P.O. Box 10454
San Antonio, TX 78210
Tel. (512) 532-6351**

**Dr. Stahl & Son
(Pulsfog)
P.O. Box 1227
Uberlingen D-777
West Germany**

**Tifa (CI) Ltd.
50 Division Avenue
Millington, NJ 07946
Telex: 136340
Tel: (201) 647-4570 and 647-4573
Cable: TIFA Stirling**

**Buffalo Turbine
(Mity Moe: SONIC ultra-low volume)
Agricultural Equipment Co., Inc.
70 Industrial St.
Gowanda, NY 10470
TWA 716-532-2210
Tel: (716) 532-2272**

**FMC Corp: John Bean Div.
516 Dearborn St.
Tipton, TN 46072**

**Gerbruder Holder, BmbH and Co.
(Holder)
P.O. Box 66
D7418
Metzingen, West Germany
Telex: 7245319
Tel: 07123-2036**

H.D. Hudson MFG Co.
(Porta-pak^R, Compression Sprayers
and Dusters)
500 North Michigan Avenue
Chicago, IL 60611
Tel: (312) 644-2830

Hatsuta Suzuki Industrial
(Hatsuta Mistblower)
Av. Monteiro Lobato 2700
Caixa Postal 9
Guarulhos 0700, Sao Paulo, Brazil
Cable: HATSUMEC
Tel: PABX 209-2133
Telex: HABR 1125046

Hatsuta Industrial Co. Ltd.
4-39, I-Chrome Chifune
Nishiyodogawa-ku
Osaka, Japan

Kioritz Corporation
P.O. Box 10
M. Taka
Tokyo, Japan

Kioritz Corporation
350 Wainwright
North Brook, IL 60062

Maruyama Manufacturing Co. Ltd.
4-15, Uchi-Kanda. 3-Chome
Chiyoda-ku
Tokyo, Japan

London Fog Company
505 Brimhall
Long Lake, MN 55356
Tel: (612) 473-5366

Lowndes Engineering Company
125 Blanchard St. Box 488
Valdosta, GA 31601
Telex: LECO VALD 810-786-5861
Tel: (912) 242-3361
Cable: LECO VALD

Micro-Gen Equipment Corporation
10700 Sentinel Drive
San Antonio, TX 78217
Telex: 9108711000
Tel: (512) 654-8570
Cable: MCROGEN

Micron West Inc.
(ULVAFAN^R portable)
8582 Katy Freeway
P.O. Box 19698
Houston, TX 77024
Telex: 792911
Tel: (713) 932-1405
Cable: MICRONW HOV

Motan GMBH
(Fontan)
P.O. Box 1260
Max-Eyth-Weg 42
D-7972 Isny, Germany
Telex: 7321 524
Tel: 07562 - 6/6
Cable: Motan ISNY

Public Health Equipment & Supply
(London Aire)
P.O. Box 10458
San Antonio, TX 78210
Tel: (512) 532-6351

Root-Lowell Corporation
1000 Foreman Road
Lowell, MI 49331
Tel: 1-800-253-4342

San Mar Tool & Equipment Company
(Root & Lowell)
50 Broadway
New York, NY 10004
Tel: (212) 797-1382

Solo Incorporated
 5100 Chestnut
 Box 5030
 Newport News, VA 23605
 Telex: (710) 823 644
 Tel: (804) 245-4228

Solo Canada Caribbean
 Deppe Ag-Tec.
 Box 464
 Burlington, Ontario L7R 3Y3
 Canada

Turbair
 (ULV Spraying Systems)
 Britannica House
 Waltham Cross
 Herts, England
 Telex: 23957
 Tel: Lea Valley (0992) 7633008

Vandermolen Corporation
 (KWH-44 Mistblower)
 119 Dorsa Avenue
 Livingston, NJ 07093

Wambo Co. Ltd.
 Postfach 102606
 D-8900 Augsburg 1
 West Germany

Whitmire Research Laboratories, Inc.
 3568 Tree Court Industrial Blvd.
 St. Louis, MO 63122

Yanmar Diesel Engine Co. Ltd.
 (ULV Knapsack)
 1-11-1 Marunouchi, Chiyodo-Ku
 Tokyo, Japan
 Telex: TOK 0220-2310
 Cable: YANMAR TOKTU

Sprayer-Hand Compression

B & G Equipment Co.
 Applebutter Road
 Plumstead, PA 18949
 Tel: (215) 766-8811

Blue Spruce International
 (Pesticide Equipment
 & Insecticide Supplies)
 1390 Valley Road
 Stirling, NJ 07980
 Telex: 136340
 Tel: (201) 647-4570
 Cable: TREE Stirling

Champion Sprayer Co.
 6581 Heintz Ave.
 Detroit, MI 48211

Clarke Outdoor Spraying Co.
 (Pesticide Equipment Supplies)
 P.O. Box 288
 Roselle, IL 60172
 Tel: (312) 894-2000

Flow Dynamics Inc.
 1333 State College Parkway
 Anaheim, CA 92806

H.D. Hudson Mfg. Co.
 (Knapsack Hydraulic and
 Hand Compression Sprayers)
 500 North Michigan Ave.
 Chicago, IL 60611
 Tel: (312) 644-2830

PARCO
 (Division of Blue Mountain Products)
 P.O. Box 250
 New Hartford, NY 13413
 Tel: (315) 797-3214

Root Lowell Corporation
 1000 Foreman Road
 Lowell, MI 49331
 Tel: 1-800-253-4342

Rodenticides

Baran (fluoroacetamide)

Archem
1514 11th Street
Box 767
Portsmouth OH 45662

Tamogan Ltd.
3 Hakhshmal Street
P.O. Box 2438
Tel Aviv, Israel

Brodifacoum

ICI Americas Inc. (Talon)
Agricultural Chemicals Division
Wilmington, DE 19897

Rodent Control Ltd.
70/78 Queens Road
Reading, Berks, England
Tel: READING 54740

Sorex Ltd.
St. Michaels Road
Widnes, Cheshire WA8 8TJ England
Tel: 051420 7151

Bromadiolone

Chempar Chemical
60 E 42nd St., Ste. 652
New York, NY 10016

Sanex Chemicals Inc.
(Bromone) (MAKI)
1307 South 30th Avenue
Hollywood, FL 33020
Tel: (305) 921-5666

Castrix (crimidine)

Bayer AG
Pflanzenschutz
509 Levenkusen Bayerwerk
Federal Republic of Germany
Telex: 8510881
Tel: 02172-301
Cable: BAYER

Calcium Cyanide

Degesch America Inc.
P.O. Box 116
Weyers Cave, VA 24486

Coumatetralyl (Racoumin)

Bayer AG
Pflanzenschutz
509 Levenkusen Bayerwerk
Federal Republic of Germany
Telex: 8510881
Tel: 02172-301
Cable: BAYER

Cymag (Sodium Cyanide)

Imperial Chemical Industries
Plant Protection Division
Fernhurst
Haslemere
Surrey, England GU27 3JE
Telex: 858270 Ic.pp Fernhurst
Tel: Haslemere (0428) 4061

ICI American Inc.
Agricultural Chemical Div.
Wilmington, DE 19897
Tel: Summerset Court (0428) 4061
Cable: Plantecton

Difenacoum (Ratak)

ICI American Inc.
Agricultural Chemical Div.
Wilmington, DE 19897
Tel: Summerset Court (0428) 4061
Cable: Plantecton

DPL-187 (Vacor)

Rohm & Haas Co.
Agricultural &
Sanitary Chemicals Dept.
Independence Mall West
Philadelphia, PA 19105
Tel: (215) 592-3032

Dipacinone

Bell Laboratories
3699 Kinsman Boulevard
P.O. Box 5133
Madison, WI 53705
Tel: (608) 256-2632

Velsicol Chemical Co.
341 East Ohio St.
Chicago, IL 60611
Telex: 910-221-5738
Tel: (312) 670-4500

Fumarin

Union Carbide
Agricultural Products Co.
300 Brookside Ave.
Ambler, PA 19002

Fival

Motomco Inc.
267 Vreeland Ave.
P.O. Box 300
Paterson, NY 07513

Red Squill

S.B. Penick & Co.
1050 Wall Street, West
Lindhurst, NJ 07071
Telex: 133525
Tel: (201) 935-6600

Prentiss Drug & Chemical Co.
363 Seventh Avenue
New York, NY 10001

Warfarin

Bell Laboratories
3699 Kinsman Boulevard
P.O. Box 5133
Madison, WI 53705
Tel: (608) 256-2632

Hopkins Agricultural Chemical Co.
Manufacturing Division
P.O. Box 7532
Madison, WI 53707

Prentiss Drug and Chemical Co.
363 Seventh Avenue
New York, NY 10001

Roberts Laboratories
4995 N. Main
Rockford, IL 61101

Velsicol Chemical Corporation
341 East Ohio St.
Chicago, IL 60611
Telex: 910-221-5738
Tel: (312) 670-4500

Zinc Phosphate

ARCHEM
1514 11th St.
Box 767
Portsmouth, OH 45602

Bell Laboratories
3699 Kinsman Boulevard
P.O. Box 5133
Madison, WI 53705
Tel: (608) 256-2632

Hooker Chemical Co.
1042-7 Iroquois Ave
P.O. Box 344
Niagara Falls, NY 14302
Telex: 91-575
Tel: (716) 278-7000

Rodenticides (Prepared Baits)

Bell Laboratories Inc.
(ZP^R, RAZE^R, PCO and FINAL^R)
P.O. Box 5133
Madison, WI 53705
Tel: (608) 256-2632

Chempar Chemical Co. (ROZOL^R)
60 E. 42nd St.
New York, NY 10165
Telex: 710-581-2318
Tel: (212) 687-3990

J.T. Eaton & Co. Inc.
1393 East Highland Road
Twinsburg (Cleveland), OH 44087
Tel: (216) 425-7801

J.E. Bolt Corporation
P.O. Box 25103
Chicago, IL 60625
Tel: (312) 327-7173

Southern Mill Creek Products, Inc.
(PARA-BLOX^R)
P.O. Box 1096
5414 56th Street
Tampa, FL 33601

Velsicol Chemical Corporation
(Promar^R and Ramik^R)
341 East Ohio St.
Chicago, IL 60611
Telex: 910-221-5738
Tel: (312) 670-4500

Special Insecticide Products

Cenol
(Insecticide Aerosols)
P.O. Box 177
Rt. 45th Peterson Road
Libertyville, IL 60048
Tel: (312) 362-6600

Cline-Buckner, Inc.
(Baygon & Diazinon Acrosols)
16317 Piuma Avenue
Cerritos, CA 90701
Tel: (213) 924-6371

Environmental Chemicals, Inc.
(Temephos formulations)
703 North Lake Shore Drive
Barrington, IL 60010
Tel: (312) 526-7744

Gold Crest Pest Control Supplies
(Rodenticides & Insecticides)
1700 Liberty
P.O. Box 5668
Kansas City, MO 64102
Tel: (816) 421-4696

McLaughlin Gormley King Co.
(Dipterex^R)
8810 Tenth Avenue
Minneapolis, MN 55427

Pet Chemicals Inc.
(Vapona Aerosols)
P.O. Box 660656
Miami Springs, FL 33166

Peterson/Puriton, Inc.
(Aerosols)
Hegeler Lane
Danville, IL 61832
Tel: (217) 442-1400

Stephenson Chemical Co., Inc.
(Aerosol Flea Control)
P.O. Box 87188
College Park, GA 30337
Tel: (404) 762-0194

Time-Mist Inc.
(Insecticide Aerosols)
135 South Main Street
Thomaston, CT 06787
Tel: (203) 283-8226

Wyco International, Inc.
(Tossit)
4811 Carnegie Avenue
Cleveland, OH 44103
Tel: (216) 391-5047

Entomology Equipment

Light Traps

CDC Miniature

Housherr's Machine Works
Old Freehold Road
Toms River, NJ 08753
Tel: (201) 349-1319

New Jersey-like

Concession Supply Company, Inc.
1016 Summit St.
P.O. Box 1007
Toledo, Ohio
Tel: (419) 241-7711

John W. Hock. Co.
P.O. Box 12852
Gainesville, FL 32604

Plastic Larval Dippers

Clarke Spraying Company
P.O. Box 288
Roselle, IL 60172

BioQuip Products Company
P.O. Box 61
Santa Monica, CA 90406
Tel: (213) 322-6636

Aerial Applications

Commercial ultra-low volume aduenticiding

Environmental Aviation Services Inc.
P.O. Box 176
Belle Glade, FL 33430
Tel: (305) 996-2369

Equipment (ULV)

BEECO Products Co.
(Beecomist spray head)
Industrial Park
Fort Washington, PA

Ciba-Pilatus and Micron Sprayers Ltd.
(Electric rotary disc atomizer)
Three Hills
Bromyard, Herfordshire HR 7 4HU
United Kingdom

Bockenstette Agricultural
Aviation Services
(CACU-Mist Mark IV)
P.O. Box 227
Abilene, KA 67410
Tel: (913) 263-2033

Micronair (Aerial) Ltd.
Bembridge Fort
Sandown
Isle of Wight, PO36 8Q3, England
Tel: Brading 461
Cable: Micronair Sandown England
Telex: 86448

Spraying Systems Co.
P.O. Box 12735
St. Petersburg, FL 33733
Tel: (813) 360-3907

Specialized Ultra-low Volume Materials

Marco Chemical Division
(HAN, heavy aromatic naphtha)
W.R. Grace & Co.
800 N.W. 36th Avenue
Miami, FL

Southern Mill Creek Products
(Tritons and HAN)
P.O. Box 420981 Allapettah Station
2490 N.W. 41st Street
Miami, FL 33601

Home & Farm Chemicals Co.
(Oil sensitive dye cards)
P.O. Box 6055
Charlotte, NC

Pierce Chemical
(Dri-film SC-87)
P.O. Box 6055
Rockford, IL

Rohm & Haas Co.
(Tritons)
Independence Mall West
Philadelphia, PA 19105

The mention of specific companies or products does not imply that they are endorsed or recommended by the Pan American Health Organization in preference to others of a similar nature that are not mentioned.

