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A PROJECT: To develop safe, effective, and economical control methods suitable and practical for small farmers to reduce crop damage by rats and noxious birds.
DURATION: 1968 ongoing
DEVELOPMENTS: Millions of dollars are lost annually in Africa, Asia, and Latin America by rat damage to rice, quelea and bird damage to small grains, and vampire bat transmitted rabies in livestock. During 1976 seven trips were made to these areas to assess the severity of vertebrate pest situations in agriculture, to arrange and conduct preliminary field trials, and to identify problems, plan programs, and provide current information. A summary of each trip is presented in this report. The most important areas of backup research in support of field programs are pharmacology, behavioral biology, sensory biochemistry, electronic development, and physiological biology. Abstracts are included of the backup research activities in these areas. Longer reports are included on the control of damage to small grains in Africa by quelea, the rodent research center in the Philippines, and vampire bat control in Latin America. Two vampire bat control methods are being evaluated in Southern Bolivia. In a study in northeastern Brazil the use of diphenadione reduced the vampire bat population by 99.4 percent. Campaigns for controlling bats are reviewed for ten Latin American countries. The programs of the Rodent Research Center are aimed at reducing vertebrate damage

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to agricultural crops in the Philippines and other countries in southeast Asia. The program emphasized adaptive research and control methods evaluation and also the development of a technical backstop capability to advise regional plant protection agencies and a training capability to encourage rapid use findings. The main objective of the DWRC in Africa is to conduct research toward protection of small grain crops, such as wheat, sorghum, millet, and rice, from depredations by birds and rodents. Preliminary work suggests that use of chemical repellents and baits for direct crop production may help to reduce damage. This report is a general review of the quelea and its depredation in Africa along with the current status and future goals of research.

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VERTEBRATE DAMAGE CONTROL RESEARCH IN AGRICULTURE

ANNUAL REPORT 1976

Denver Wildlife Research Center
U.S. Fish and Wildlife Service

U.S. Agency for International Development

10/11

1976 ANNUAL PROGRESS REPORT*

COOPERATING AGENCIES:

U.S. Fish and Wildlife Service

U.S. Agency for International Development

Agricultural Agencies in Africa, Asia, and Latin America

*RESULTS INCOMPLETE AND NOT FOR PUBLICATION, RELEASE, OR USE WITHOUT AUTHORITY OF THE DIRECTOR, DENVER WILDLIFE RESEARCH CENTER.

This research was conducted with funds provided to the U.S. Fish and Wildlife Service by the Agency for International Development under PASA's "Control of Vertebrate Pests: Rats and Noxious Birds," ID/TAB-473-1-67, and "Control of Vampire Bats," ID/TAB-000-10-76.

The Cover

The photographs on the cover (from left to right, top to bottom) illustrate the scope of research involved in the AID-sponsored International Programs of the Denver Wildlife Research Center.

The common vampire bat has caused economic loss and hardship for livestock producers of Latin America. The transmission of paralytic rabies and possibly other diseases, blood loss, myiasis, and reduced production contribute to a multimillion dollar problem.

Systemic treatment of cattle by intraruminal injection of the anticoagulant Diphenadione is one of two highly effective, safe, and economical means of vampire bat control developed by DWRC researchers.

Rodents cause severe losses of coconuts in almost all countries where they are grown. A control method developed by DWRC biologists has yielded dramatic results in field tests in Latin America and the Philippines.

Quantification of the magnitude of food losses to vertebrate pests on a worldwide basis is meager at best. Many of the published discussions of food losses inevitably focus on microorganisms or arthropods and make only passing mention of vertebrate pests. The development of reliable survey methods for vertebrate damage problems will result in a greater appreciation of the role of vertebrate pests in food losses.

Backup research at DWRC by specialists in such fields as toxicology, animal behavior, physiology, bioelectronics, and chemistry play a major role in the development of effective control methodology.

Vertebrate damage in agriculture involves a variety of crops and species of animals (primarily birds and rodents). Direct losses occur typically at planting and sprouting, during the milk or dough stages (for grains), just before harvest, or under postharvest storage conditions. Some damage may be mechanical, as when crops are trampled or dislodged by animals digging for insects or other food. Losses may alter the food value, as when rats selectively remove the germ from stored corn, or may result from the contamination of foods with urine, feces, feathers, or hair.

In many areas of the world, rodent damage to field crops causes severe reduction of the human food supply, and increases the risks of small-farm agriculture. In localized areas, rodents may be a principal factor limiting crop production; more often, rodents unobtrusively remove a share of production before harvest--crop after crop, season after season. Although there are more than 6,000 kinds of rodents, only about 50 could be considered significant agricultural pests.

A central difficulty in the development of vertebrate damage control technology in many countries has been a tendency to ascribe minor importance to species and environmental differences and to attempt translation of work from the laboratory to field areas where different species, crops, and environmental factors are involved. Hence, on-site field testing is prerequisite to a successful program. In addition, such an approach affords excellent opportunities for training of local specialists who will ultimately bear the responsibility for vertebrate damage control programs in their countries.

Losses to birds are less well documented than those to rodents. Various species of parrots and parakeets, blackbirds, weavers, doves, seedeaters, pheasants, and waterfowl are among the types of birds known to cause damage in agriculture around the world. Data on crop loss are difficult to assess because damage is usually concentrated on limited areas and, due to the mobility of birds, is often seasonal, sporadic, and difficult to predict.

Vertebrate damage control research of the DWRC involves evaluation of different methods which include chemical, physical (such as this sublethal electric barrier), biological and other techniques which have the potential of providing positive benefits in the control of vertebrate damage in agriculture. The species, crop, farming methods, environmental factors, and a host of other considerations may influence the approach to solution of a particular problem.

The Denver Wildlife Research Center is well equipped with modern, scientific instrumentation, providing the capability for laboratory research into all facets of a vertebrate damage problem.

The results of research undertaken by DWRC staff members and cooperators around the world are regularly published in scientific and technical journals, progress reports, and special publications, often in the language of the country or countries suffering a particular pest problem. Nearly 200 publications have resulted from the international activities of the DWRC since initiation of the program.

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SUPERVISION AND SUPPORTING ACTIVITIES OVERSEAS

PRINCIPAL INVESTIGATORS:

John W. De Grazio, G. Clay Mitchell,
Michael W. Fall, Nelson B. Kverno,
Jerome F. Besser, and Donald F. Mott

INTRODUCTION

The basic project goal of the Section of International Programs is to increase the available human food supply in the less-developed countries by reducing damage to field crops caused by rats and noxious birds. The ultimate aim of this research program is to develop safe, effective, and economical control methods suitable and practical for small farmers and acceptable in the broader context of agricultural development.

Examples of economic impact caused by vertebrate pests in the less-developed countries are:

1. $250 million lost annually in Latin America due to vampire bat-transmitted rabies in livestock (FAO estimate). Funded under a separate PASA.

2. $50 million lost annually in the Philippines due to rat damage to rice (DWRC estimate).

3. $8.5 million lost annually in Africa due to quelea damage to small grains (FAO estimate).

4. $0.9 million lost annually in Uruguay due to bird damage to small grains (Ministry of Agriculture estimate).

Program goals are accomplished, in part, by (1) in-country programs, (2) TDY activities from the DWRC requested by AID/Washington or AID Missions, (3) supervisory and administrative functions from the DWRC and AID/Washington, and (4) problem-oriented research activities at the DWRC through the Sections of Supporting Sciences, Bird Damage Control, and Mammal Damage Control.

Vertebrate pest damage problems in Africa, Asia, and Latin America are continuously reviewed. Current bird and mammal damage control research is also reviewed with the aim of adapting new techniques or materials to problem situations. These activities require field visits, liaison, and on-going interchange with pest control research and implementation programs of other organizations--both domestic and foreign.

The supervisory activities provide support and direction to field personnel, assist in establishing relevant research objectives for laboratory personnel, and coordinate the team efforts of DWRC scientists. General administrative support is provided in areas of fiscal management,

personnel matters, commodity procurement, and coordinating correspondence, reports, and manuscripts. Related duties include representing the program with other organizations, coordinating DWRC-based training for AID participants, briefing visitors, developing cooperative programs with other international organizations, providing technical information to USAID Missions or other cooperators, and assisting AID personnel in program negotiations with foreign governments.

Personnel

Personnel of the Section of International Programs stationed at the Denver Center are:

John W. De Grazio	- Section Chief responsible for supervision and coordination of research activities; organizes or participates in outreach activities for control of rats, bats, or birds as required.
G. Clay Mitchell	- Biologist responsible for outreach activities in Latin America on the vampire bat program.
Michael W. Fall	- Biologist responsible for outreach rodent control activities as required in Asia, Latin America, and Africa.
Donna J. Scott	- Serves as Program Assistant to the Section.

Personnel stationed overseas are:

Russell F. Reidinger	- Rodent Research Center (National Crop Protection Center), Los Banos, Philippines--working with 28 Filipino counterparts.
Wayne H. Bohl	- Plant Protection Department, Khartoum, Sudan --working with about 10 African counterparts.

Ten people in the Section of Supporting Sciences are partially supported with AID funds. Personnel from other Sections within the Denver Center, such as the Sections of Bird Damage Control and Mammal Damage Control, provide assistance as required. In addition, the Section of International Programs may call on the services of more than 100 professional scientists from other units of the Denver Center and the U.S. Fish and Wildlife Service.

During 1976, seven trips were made to various countries in Africa, Asia, and Latin America. Objectives of these visits were to:

(1) assess severity of vertebrate pest situations in agriculture, (2) arrange and conduct preliminary field trials, and (3) identify problems, plan programs, and provide current and useful information to government and Aid Mission personnel.

A summary of each trip is presented below; detailed information is contained in individual trip reports held in DWRC files.

AFRICA

Rodent Control in Senegal: Present Problems, Future Needs. M. W. Fall and AID-ADO/Dakar, February 1976

The Sahelian Region has suffered for two seasons following the drought from extraordinarily high rodent populations involving several species. Some of the rodents involved occupy most major habitats; their visibility has raised rodent control from an "unimportant" agricultural concern to a focus of national attention in the context of an emergency program to protect crops. The program planned by the Government of Senegal would involve the use of more than 2 billion F. CFA or about $10 million (U.S.) in prepared rodenticides and grain incentives during the next 8-9 months. Clearly this kind of effort, if possible at all economically and logistically, cannot be sustained for long or repeated periodically, and work must be undertaken to develop effective control methods using a local materials base. Efficient operation of a large agricultural implementation program requires numbers of trained personnel--in this situation, trained in the specific techniques of effective rodent damage reduction. Talented government personnel in Senegal are making great efforts to carry out a successful program and additional training is planned in the course of the field campaign in rural areas. However, the magnitude of the problem and the need for quick action to protect remaining dry-season crops probably will make the shortage of trained personnel a critical factor in the initial program.

Various environmental sanitation methods should be tried to reduce damage to small garden plots and village food stores--perhaps as an alternative or in conjunction with planned physical killing campaigns. Local authorities should be briefed on pesticide safety and treatment of accidental poisoning, and arrangements should be made for epidemiological assessment of the potential for rat-borne disease transmission. As soon as possible, evaluation studies and training programs should be organized on a regional basis to make effective rodent control a permanent part of Sahelian agriculture.

ASIA

Status of Vertebrate Pest Management Programs in Asian Countries. M. W. Fall, August-September 1976

Visits to six Asian countries were made to help coordinate work by USFWS research projects in Denver and the Philippines with that underway in other areas. In addition, field observations aimed at development of approaches to reduce rodent damage to cereal grains were continued in Nepal, and arrangements were made to carry out cooperative field trials of control techniques with the Nepal Department of Agriculture and the USAID/MUCIA project in southern Nepal. The USAID/CARE rodent control project in Indonesia, to be backstopped by DWRC, has not yet reached the stage of establishment of a field headquarters; further delays may be anticipated.

Work at the Rodent Research Center in the Philippines is progressing well on all studies. This project will be assimilated in January by a new National Crop Protection Center and seven regional field stations. USFWS staff will continue to focus on development or evaluation of methods to control rodent damage to rice; however, efforts to adapt current methods to other crops and to develop means of reducing bird damage to emergent and maturing grains should be intensified.

LATIN AMERICA

Investigations of Methods to Control Monk Parakeet and Eared Dove Damage to Crops in Uruguay. D. F. Mott, J. F. Besser, and C. Calvi, February-March 1976

The purpose of this trip was to initiate field experiments designed to reduce monk parakeet (*Myiopsitta monachus*) damage to ripening sunflowers and field corn and eared dove (*Zenaida auriculata*) damage to ripening grain sorghum. Testing was conducted in cooperation with Uruguayan Ministry of Agriculture personnel.

It was found that (1) parakeets can be affected by spraying ears of corn with a 12% formulation of Avitrol, (2) fewer were observed using the field on days after ears were sprayed, (3) Avitrol-affected parakeets seldom vocalized, and (4) field should be treated when the first ears are damaged.

Spraying sunflower heads with a 16% Avitrol formulation appeared to reduce the number of monk parakeets using the field on days following spraying and it was noted that affected birds caused feeding flocks to leave the field.

Aerial application of methiocarb appeared to reduce dove damage. Results at Nueva Mehlem were more impressive than at La Nona where a small difference in the amount of grain taken in sprayed and unsprayed plots was recorded. The degree of protection may have been related to the amount of chemical actually applied to the grain. The amount of chemical deposited on the grain heads at the two sites may have been different due to the type of plane spray system and/or wind velocity at time of application.

Agricultural Rodent Control in Venezuela. M. W. Fall, March 1976

At least two species of cricetid rodents have caused serious damage to agricultural crops in Venezuela during the current crop year. A variety of control approaches being attempted by Venezuelan farmers appear ineffective from a crop protection standpoint and, in some cases, hazardous.

With the help of Venezuelan Government officials, provisional guidelines for rodent control in rice using sustained baiting were developed for preliminary testing in the current crop. However, since this approach is labor intensive and was developed for small farms in Southeast Asia, it is doubtful that Venezuelan farmers will find it well-suited to their large, mechanized farms.

The Venezuelan Government also plans to undertake a long-term research program to address problems of vertebrate damage to agricultural crops. USFWS biologists may be asked to assist in initiating preliminary research and field trials to reduce rodent damage to rice in Venezuela, and in training program personnel.

Vertebrate Pest Situations and the State of Knowledge in Uruguay, Paraguay, and Bolivia. N. B. Kverno, July 1976

The purpose of the trip was to assess the severity of vertebrate pest situations in agriculture and the state of knowledge in Uruguay, Paraguay, and Bolivia, and to make recommendations regarding a course of action.

Over the past several years, staff members of the Denver Wildlife Research Center have, on a TDY basis, conducted field tests on bird problems in grain crops in southwestern Uruguay. They reported three families of birds involved in the damage: doves, parakeets, and blackbirds. More recently, they identified a duck problem in rice in the Southeast. The Ministry of Agriculture considers these pest situations to be of major significance. Vampire bats exist in sufficient numbers in some sections of the country to cause concern. Vampire bat-transmitted rabies, however, has not been verified in Uruguay nor have there been any major livestock losses suspected of being caused by rabies. There is no evidence to support the existence of any agricultural rodent problems of significance.

Assessment of the vampire bat problem in Paraguay by local authorities ranged from severe to negligible. Staff members of the University's Department of Veterinary Medicine reported that bat-transmitted rabies is a problem of major importance in cattle production and is exceeded only by aftosa and brucellosis. Others, however, question that rabies is an important disease of cattle and are not convinced that it has even been diagnosed. Based on comments of authorities in Asuncion, including the agriculture extension officers, it would appear that there are some bird damage situations but they are not severe and probably erratic in occurrence.

The state of knowledge of the bird problems in Bolivia is not much different from that in Paraguay. The officials in Santa Cruz did not have first-hand knowledge of any problems but received occasional reports of some damage to rice by doves and "Roedores" (a small dark rat). To more fully assess the problem, it would require field trips into the major crop areas and talking with the local officials and the growers. It might also require a return trip during the season of alleged damage to determine the severity of the problem. There is considerable interest in controlling vampire bats, and from all reports, the problem is one of major importance to the cattle ranchers. Discussions centered around a study plan to comparatively evaluate the rumen injection method and the topical treatment for bat control.

Rodent Damage Problems in the Bajo Aguan and Choluteca Regions. J. W. De Grazio, September 1976

The Government of Honduras is faced with a severe problem of rodent damage to agricultural crops and needs current information and assistance to develop methods of reducing losses.

In the Bajo Aguan Valley, rodent damage to corn is the most important problem; in the Choluteca area, rodent damage to sugarcane, corn, rice, melons, and cotton are important problems. The Government estimates there are about 400 rats per hectare in the Bajo Aguan Valley and about 8-20% or more of the corn crop is lost annually. In Choluteca, estimated losses vary from 10-50% annually. Other agricultural crops are also affected by rodents and birds.

It is recommended that the Government of Honduras, through the Ministry of Natural Resources, institute a long-term program that would combine research and operational aspects of control campaigns which will result in a permanent part of Hondurian agriculture. Basic information is needed on damage, population cycles, species composition, rodenticide formulations, and baits and bait placement to better determine if control programs are working and damage is being reduced.

Assistance can be provided from the Denver Wildlife Research Center by supplying current information on vertebrate pest control, by helping to initiate basic field and laboratory tests, and by short-term training at the Denver Center for one or two key individuals.

Trip Report: Colombia, Panama, Nicaragua, and Honduras. G. C. Mitchell and M. W. Fall, November 1976

DWRC personnel worked with Ministry of Agriculture/Colombia officials to establish a regional vampire bat control program near Santa Marta, Colombia. Vampire bat control was discussed with Ministry of Natural Resources officials in Honduras. Vampire bat-transmitted rabies is endemic in a 50-square-mile area near La Ceiba, Honduras.

AID personnel in Panama and Nicaragua were consulted on ratproofing storage facilities and rodent control to standing crops.

BACKUP RESEARCH - DENVER WILDLIFE RESEARCH CENTER

PRINCIPAL INVESTIGATORS:

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Stephen A. Shumake, Ray T. Sterner, Roger W. Bullard,
A. Lawrence Kolz, Brad E. Johns, Donald J. Elias,
Iwao Okuno, and Thomas J. Leiker

INTRODUCTION

The Section of Supporting Sciences provides backup research in support of field activities on vertebrate damage problems. A staff of specialists in such fields as toxicology, animal behavior, physiology, bioelectronics and chemistry, utilizing modern scientific instrumentation and facilities, provide the capability for laboratory research into all facets of a vertebrate damage problem. It would be impractical, if not impossible, to duplicate this team of specialists and specialized equipment at the overseas field stations. The areas and objectives of backup research deemed most important in support of field programs are described below.

Pharmacology-Formulation

Conducts bioassay tests and provides efficacy and toxicological data to AID personnel on chemicals that are in advanced stages of development. Areas of research include species-specific toxicants, chemosterilants, repellents, and the use of potentiators and microencapsulation techniques to increase effectiveness of chemicals. Investigates physiological marking agents for identification of animals. Studies bait formulation techniques that would be applicable for delivery of chemicals to pest species of rodents and birds.

Behavioral Biology

Conducts laboratory and field studies with selected rodent and bird pest species to evaluate, improve, and develop selective lethal and nonlethal methods for reducing crop damage. Evaluates flavor additives and masking agents to improve efficacy of field baiting programs. Examines the behavioral stress and repellent effects of visual, ultrasonic, olfactory, taste and gastrointestinal stimuli on these species. Develops behavioral test standards to assess chemical compounds for repellent, attractant, or stress-producing effects. Studies natural behavior of pest species under simulated field conditions to evaluate and explore new approaches to vertebrate damage control.

Sensory Biochemistry

Responsible for experiments involving chemical aspects of sensory behavior and physiology. Tests chemical concepts potentially useful in developing new control methods or materials for use with old ones. Explores the familiar food concept of developing rat attractants or bait enhancers. Attempts synthetic duplication of rice aroma to increase the effectiveness of rodent baiting programs. Tests properties of plant product oils that lead to increased bait acceptance. Selects and formulates chemicals for a rodent and bird food preference testing program, and relates structural relationships to biological activity. Assists with problems relating to sensory influences of animal damage control chemicals.

Electronic Development

Develops and produces electronic instrumentation for studies related to ricefield rat populations in the Philippines and Latin America. Conducts research to develop wildlife transmitters for use on quelea birds in Africa. Searches for and develops new methods of remote sensing, data collection, and laboratory recording; to improve the researchers' capabilities in conducting research; to contract with private industry for the development of specialized equipment; and to provide electronic techniques currently unavailable; and to publish and disseminate information to the scientific community.

Physiological Biology

Conducts laboratory and field studies of a physiological nature on selected pest species involved in the AID programs. Research emphasis is on quelea birds and ricefield rats. The areas being investigated include bioenergetics, nutrition, hematology and reproductive physiology to examine functional aspects of each species that can be exploited for control purposes.

ABSTRACTS

Backup research activities in support of the International Programs field projects are briefly described below.

Rodenticide Evaluations

Assessment of PP 581 in Wild Norway and Ricefield Rats

PP 581, the brominated analog of difenacoum was very effective in free-choice feeding tests. In 6-day feeding tests with concentrations as low as 0.001%, 95% mortality was recorded in wild Norway rats. Eighty percent of ricefield rats fed 0.002% for 3 days died. Mortalities were recorded in male albino rats fed tissue from wild Norway rats that were killed with PP 581.

DRC-6276: Highly Toxic, but Acceptability is a Problem

DRC-6276 (Abbott 40458) is highly toxic to wild Norway rats. The acute oral LD_{50} in males is 1.6 mg/kg and for females it is 2.2 mg/kg. Free-choice feeding tests with baits containing 1.0% or 0.5% DRC-6276 were not encouraging. Mortalities ranged from 50 to 60% but acceptability was a major problem. All rats consumed less than 0.5 g of treated bait.

Bait Formulation Studies

Methiocarb, an Effective Repellent for the African Finch (*Quelea quelea*)

An avian repellent recently registered in the United States has been shown to be effective with several species of birds. An R_{50} value of 0.00157% was determined with caged quelea, in which the birds were offered a choice between treated millet (millet being a preferred food) and grain sorghum. These results indicate that quelea are highly sensitive to methiocarb.

Wax Bait Formulations for Philippine Ricefield Rats

A wax bait consisting of 35% wax, 64% ground rice, and 1% talc containing 0.05% warfarin was developed for use in and around ricefields in the Philippine Islands. Preliminary results on caged ricefield rats were encouraging, and the formulation will be field tested.

Avitrol (4-aminopyridine) Baits for African Finches (*Quelea quelea*)

Hulled millet treated with 2.5% or 3.0% Avitrol produced good results in caged quelea. These baits have been submitted to the field station in Africa for evaluation.

Physiological Markers for Mammals and Birds

Iophenoxic Acid for Mammals

Commercial sources for both iophenoxic acid and reagents used in its determination were located. Tests to evaluate its potential as a physiological marker in rodents were initiated. In cooperation with the Section of Predator Damage Control, iophenoxic acid is being evaluated as a marker for coyote drop baits.

Fluorescent Chemicals for Birds

Preliminary laboratory tests have shown that a chemical will mark feathers of birds 70 to 90 days after application. More detailed tests will be conducted during 1977.

Viruses Fail to Show Potential to Serve as Physiological Markers in Birds

Research conducted by the University of Wisconsin in both red-winged blackbirds (*Agelaius phoeniceus*) and African finches (*Quelea quelea*) has shown that viruses would not be practical as serological marking agents.

Behavioral Studies

Evaluation of a Device for Studying Baitshyness in Rats: Bait-Consumption Patterns of Ricefield Rats Fed Select Concentrations of Warfarin and Zinc Phosphide in Rice

Four groups of three ricefield rats each were fed ground rice containing 1 LD_{50}/day warfarin, 1 LD_{50}/day zinc phosphide, 5% cellulose, and untreated ground rice. Visual inspection of these data revealed that the rat feeding patterns were characterized by 7-10 bouts of 5- to 15-minute feedings per day.

Behavioral Response of Quelea to Methiocarb

The R_{50} value (a measure of repellency analogous to LD_{50}) for methiocarb in quelea was found to be 0.015% (w/w) with a 95% C. L. of 0.011-0.021%. These values are low in comparison with R_{50} values established for many domestic bird species, indicating that methiocarb may have a high potential for alleviating quelea damage to agricultural crops in Africa. When taste and color stimuli were added to methiocarb treated millet seeds, quelea showed conditioned repellency toward the taste cue for 2 weeks after exposure. This cue-conditioning effect could also have potential as a means of more quickly repelling birds from agricultural crops, and directing birds toward noncrop food sources.

Investigations of Variables Affecting Ultrasound Repellency in *Rattus rattus mindanensis*

Three ultrasonic rodent repellent devices (20 kHz, 20-30 kHz, and 40 kHz) were tested under four different semi-field conditions. At full intensity (118 dB), the 20 kHz device consistently produced the greatest repellent effects on feeding and rat activity. By confining the rats to sound-attenuating test chambers for several days before exposure to the ultrasonic devices, it was possible to demonstrate almost complete repellency with this 20 kHz unit. However, when the intensities of all devices were reduced 30 dB (simulated distance of 35 feet from the source), no repellent effects were shown for any of the devices.

Nonlethal Electric Barriers for Control of Ricefield Rats

Three nonlethal electric barrier designs were evaluated in a laboratory observation chamber. A prototype design with two ground and two active electrodes spaced 6 inches apart produced fewer rat barrier crosses than the other two designs. Lowering the electrodes to a height 2 inches above ground level had the effect of shocking more animals, but some degree of efficacy was lost. A plastic fish-net material substituted for 1/2-inch chicken wire backing appeared to offer a way of reducing costs; however, rat gnawing and biting of the plastic net could pose barrier maintenance problems.

Sensory Chemistry

Olfactory Response of Rats to Rice Aroma

Rice baits are made more acceptable to *R. r. mindanensis* by enhancing the volatiles fraction. However, suitable measurements of the "drawing power" have not been made. A preliminary evaluation of this was made by comparing the response of rats to the odor from rice oil with that from lab chow. The response to rice oil was considered to be strong enough to warrant further testing.

Chemical Protection of Growing Plants

This concept is being investigated as an alternative to traditional baiting methods. Our initial objective is to conduct a study that will determine the feasibility of applying chemicals topically or systemically to protect rice, corn, and beans from rat damage. The initial phases of this study are discussed.

Bioelectronics

Wildlife Transmitter Production

Custom designed wildlife transmitters were constructed in quantity for the Denver Center's Section of International Programs.

Equipment Selection for High-Voltage Barriers

Effective high-voltage animal barriers which have good reliability, require infrequent operating maintenance, and are safe for personnel can probably be designed with commercial equipment. Toward these goals, data for various fence chargers are being compared, and a wind generator is under test as a self-contained power source for remote areas.

Analytical Methods Development

Gel Permeation Chromatography for Sample Cleanup

Several gel permeation chromatographic systems were investigated to find a suitable one for separating diphacinone and warfarin from plant and animal extracts. Best separations were obtained with a system consisting of Bio-Bead S-X2 gel as the stationary phase and carbon tetrachloride as the mobile phase.

Modification of the Benzophenone Method for Diphacinone

The benzophenone method for determining residues of diphacinone was modified to facilitate analysis of high-fat samples. Modifications include incorporating gel permeation chromatography for sample cleanup and using a flame ionization detector for gas chromatographic measurements.

Development of an Analytical Method for Warfarin

A tentative method has been developed for determining warfarin residues in ricefield samples. Warfarin is converted to its methyl ether which is measured by gas chromatography. Approximately 10 ng can be measured by the flame ionization detector and about 0.5 ng by electron capture.

Development of an Analytical Method for Methiocarb

The gas chromatographic method that was developed enables separate measurements of methiocarb and its two metabolites, the sulfoxide and sulfone.

Determination of Zinc Phosphide in Bait Formulations

The analytical method for zinc phosphide in bait was evaluated. Sample homogeneity, acid strength, and hydrolysis time were investigated.

An Analytical Method for Avitrol

An analytical method was developed for determining Avitrol in rice stalk and grain, soil and water. The method is simpler and shorter than two methods previously developed for corn and sunflower seeds, and has sensitivities of 0.01 ppm for water, and 0.1 ppm for stalk, grain, and soil.

CONTROL OF DAMAGE TO SMALL GRAINS IN AFRICA BY QUELEA

PRINCIPAL INVESTIGATORS:

Laboratory Studies: Gilbert J. Maede, G. Clay Mitchell, Mike G. Ngala, David N. Manyanza, and Loti Kivuyo

Field Studies: Wayne H. Bohl, John W. De Grazio, Mike G. Ngala, Loti Kivuyo, and Francis Kitonyo

ABSTRACT

The Vertebrate Pest Research Program for quelea, a cooperative endeavor of USAID, DWRC, and EAC, was established at TPRI, Arusha, Tanzania, in December 1975. A Wildlife Research Biologist from DWRC entered on permanent duty in April 1976 and prepared various research studies and reports until termination of the project February 28, 1977. Research activities of 1976, along with those of earlier DWRC field trips to Africa from 1971 through 1975, are reported upon an summarized.

A summary of the current status and future goals of the program for Africa is presented also. As a contribution to quelea researchers in Africa, three TPRI Miscellaneous Reports, Nos. 932, 933, and 934, were prepared for dissemination.

INTRODUCTION

Bird damage to agricultural crops has been a chronic problem in many parts of the world. The black-faced dioch or red-billed weaver (Quelea quelea) has long been a serious pest species to small-grain farmers throughout Africa. The quelea has the distinction of being the most numerous and perhaps the most destructive bird in the world.

Damage caused by quelea was noted by the earliest Portuguese explorers in Africa and began to cause official concern in 1890. Since then, major research in Africa has been directed by the British, French, and Germans through technical assistance programs. Presently, four international organizations--the U.S. Agency for International Development (AID), the UNDP Food and Agriculture Organization (FAO), German Technical Assistance (GTA), and the Centre for Overseas Pest Research (COPR)--have active quelea research programs in Africa. In addition, many African countries affected by quelea have operational control teams or organizations actively combating the problem.

While considerable progress has been made by these different groups in some aspects of the basic biology of quelea and in control at its nest and roost sites, large-scale campaigns to reduce the numbers of quelea in several African nations have provided only limited relief from bird depredations. This strategy has been costly and potentially hazardous. To be useful, a control method must be economical as well as effective, safe, available to and usable by the people affected, and its value and methods of employment must be made known and available to the farmer.

In March 1975, AID signed a Memorandum of Understanding with the East African Community to conduct vertebrate pest research cooperatively with the Tropical Pesticides Research Institute (TPRI), Arusha, Tanzania, for the benefit of the East African Community member countries (Tanzania, Kenya, and Uganda). Prior to this agreement, Denver Wildlife Research Center (DWRC) personnel had conducted quelea surveys in seven African countries between 1971 and 1974. The primary objective of the DWRC in Africa is to conduct research toward protection of small-grain crops, such as wheat, sorghum, millet, and rice, from depredations by birds and rodents. Preliminary work on problem assessment and evaluation of selected chemicals, such as methiocarb and Avitrol[R]* in Africa suggests that use of chemical repellents and baits for direct crop protection may be a promising strategy for reducing damage.

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*Reference to trade names does not imply endorsement of commercial products by the Federal Government.

The development of a viable pest management capability requires research, training, and institutionalization of the program. To accomplish this goal, cooperative studies are encouraged with the research teams in Africa and communication links developed for the exchange of information. The research program is problem oriented, and the investigations are applied through appropriate plant protection rather than killing quelea, which has been shown to be ineffective in reducing losses. DWRC uses a team approach to problem solving and has technical capabilities, scientific equipment, and a staff of over 100 professional scientists who can provide support to their overseas programs.

In late 1975, four laboratory studies were initiated by Dr. Clay Mitchell, on temporary assignment from DWRC, with the staff of the TPRI Bird Pest Section. The four studies included the Load-lifting Capacity of Quelea quelea, Food Preference of Quelea quelea, Breeding Quelea quelea in Captivity, and Retention of Leg Streamers by Quelea quelea.

Mr. Wayne H. Bohl replaced Dr. Mitchell at TPRI in April 1976 as permanent DWRC Research Biologist. Main objectives were to work with TPRI in the completion and reporting of the four laboratory studies, and to implement as quickly as possible damage appraisals and damage assessment/replicate field research for the East African Community, leading to direct protection of cereal crops from the quelea and other noxious birds.

Due to unforeseen difficulties, the AID and DWRC Vertebrate Pest Research and Control Program for East Africa was terminated with EAC in Tanzania in February 1977. The program will be transferred to Sudan in May 1977 where the same main objectives will be pursued over the next several years.

This progress report presents a general review of the quelea and its depredation in Africa, 1971-1976, along with the current status and future goals of research for the African Program.

GENERAL INFORMATION ON QUELEA IN EAST AFRICA

Considerable information on quelea has been published and is presented here in table form, as previously tabulated by De Grazio (1973, 1974). Specific scientific reports utilized in the tabulation were by Ward (1971, 1972) and Haylock (1959). Additional basic field observations concerning excellent knowledge of quelea habits, crops being damaged, and areas where damage occurs were provided by Messrs. F. Kitonyo and E. Mosha, Ministry of Agriculture, Division of Crop Protection (Bird Control), Kenya and Tanzania, respectively. All of the information provided is summarized in Tables 1, 2, 3, and 4.

The DWRC research work in Africa from 1971 through 1974 is summarized below.

1971 Chad

- Quelea reacted to Avitrol (a fright-inducing agent) in cage tests
- Quelea repelled by 0.1% methiocarb (a repellent)
- Seventeen chemicals evaluated on quelea--dermal and oral LD_{50} established
- Literature surveyed - Data on problem assembled

1972 West Africa

- Surveyed bird problems in Senegal, Ghana, Liberia, Nigeria, Chad, Cameroon
- Avitrol test in Chad - not effective

1973 East and West Africa

- Surveyed bird problems in Ethiopia, Kenya, Tanzania, Sudan, Somalia
- 2% Avitrol test on wheat in Chad - partly effective
- 2% Avitrol test on sorghum and millet in Kenya - partly effective
- 3.2% methiocarb on wheat in Chad - partly effective

1974 East Africa

- 1.5 lb/acre methiocarb on wheat in Kenya - partly effective
- 3 lb/acre methiocarb on wheat in Kenya - effective
- 3 lb/acre methiocarb on rice in Tanzania - effective
- Gathered information on bird problems in Morocco
- Initiated negotiations with Tropical Pesticides Research Institute (TPRI), Arusha, Tanzania, to serve the East African Community (EAC) by placing a Wildlife Biologist at Arusha

1975 East Africa

- Project established December 1975
- Four laboratory studies initiated: Load-lifting Capacity
  Food Preference
  Breeding in Captivity
  Retention of Leg Streamers

1976 East Africa

- Biologist on board April 1976
- Damage surveys in Kenya/Tanzania

  (Project terminated February 28, 1977)

Table 1. Habits, migratory pattern and breeding of *Quelea quelea* in East Africa (DWRC 1974 Annual Report)

Habits

- Natural habitat - semiarid acacia - rely on natural seeds
- Never distributed evenly - concentrate where food and water abundant
- Can forage up to 20 miles from roost
- Feeding time - daylight to 10:00 a.m. and 2:30 p.m. to late evening
- Use staging areas on return to roost
- Roost usually in acacia, scrub, bulrush and tall grass
- May roost from 20,000-250,000/acre
- Split into groups of 50-5,000 for day's feeding
- Require water several times daily

Migratory Pattern

- June-Oct - Quelea concentrate on grasslands of central and northern Tanzania
- Nov - North migration begins
- Nov-Dec - Minor breeding in southern Somalia
- Nov-Jan - South migration begins
  Dec - breed in southern Kenya
  Jan - breed in northern Tanzania
- Feb-Mar - Major breeding in central and southern Tanzania
- Apr-June - Second north migration - may breed in same areas as Dec-Jan
- Young birds migrate more slowly than adults and do most damage

Table 1 (continued)

Breeding

- Colonies 20-500 acres, acacia preferred.
- Males arrive first, begin nest building and display
- After female attracted, copulation and male completes nest
- Nest building continues while eggs are being laid
- Avg. no. eggs/nest 3
- Male and female brood eggs, females at night
- Some males roost near nest, most roost together just outside nesting area
- Insects and sweet annual grass seeds are fed young
- Young are fed by regurgitation
- Both parents feed young, may forage up to 15 miles from colony
- Food first days - grass seed, insects, water
- Food fifth day - primarily seeds
- On fifth day, young birds crop functional
- Seeds are Seteria, Echinochloa, Panicum, Sorghum, Eragrostis, Digitaria, etc.
- Movement away from colony - adults leave after young fledged - young remain close to colony and move when food becomes scarce
- Nesting density varies - 100-1,500 nests/bush and 20-150 bushes/acre.
- Avg. cycle of a breeding colony:

Nest building to laying	4-6 days
Incubation	9-10 days
Hatching to flying	12-14 days
Flying to leaving colony	5-6 days
TOTAL	30-36 days

Table 2. Bird damage problems in Kenya, Quelea Control Unit, Ministry of Agriculture (DWRC 1973 Annual Report)

SPECIES	CROP AFFECTED	STAGE	TIME PERIOD	AREA
Quelea quelea aethiopiea (Sudan Dioch)	Wheat	Milk	December - January and April - August	Rift Valley and Central Provinces
	Sorghum	Milk	January - March	Eastern Province
	Bulrush Millet	Any stage	January - March	Eastern and Central Provinces
	Finger Millet	Any stage	January - March and April - August	Eastern, Rift Valley, Nyanza, and Western Provinces
	Rice	Milk	Year-round	In respective schemes in Northern, Western, Central, and Coast Provinces
Chestnut Weaver	Wheat	Any stage	December - January and April - August	Rift Valley and Central Provinces
	Sorghum	Any stage	January - March	Eastern Province
	Bulrush Millet	Any stage	January - March	Eastern and Central Provinces
	Finger Millet	Any stage	January - March and April - August	Eastern, Rift Valley, Nyanza, and Western Provinces
	Rice	Any stage	Year-round	In repsective schemes in Nyanza, Western, Central, and Coast Provinces
Other weavers that feed on small grain	Wheat	Milk	December - January and April - August	Rift Valley and Central Provinces
	Sorghum	Milk	January - March	Eastern Province
	Bulrush Millet	Any stage	January - March	Eastern and Central Provinces
	Finger Millet	Any stage	January - March and April - August	Eastern, Rift Valley, Nyanza, and Western Provinces
	Rice	Milk	Year-round	In respective schemes in Nyanza, Western, Central, and Coast Provinces

N.B. The above given chart for crops with approximate time for damage and areas grown is more or less correct though sometimes will be affected by the rain start and the introduction of same crops to other provinces.

Table 3. Quelea damage in Kenya (DWRC 1974 Annual Report)

CROP	TIME	DAMAGE AREAS		WEATHER PATTERN			BREEDING SEASONS	OTHER
		GENERAL	SPECIFIC	DRY	LONG RAINS	SHORT RAINS		
WHEAT	Jul-Nov	West	Kitale El Doret	May-Jun	Jul-Dec	Feb-Apr	Aug & Mar	Emergent Damage Nyeri Nanyuki Mar-Apr Sep-Oct
	Jul-Aug		Narok					
	Dec-Jan	Central	Nyeri Nanyuki	May-Jun	Jul-Dec	Feb-Apr	Aug & Mar	
	Jun-Oct		Nakuru Nyanadura					
RICE	Varies	West	Ahero Bunyala					
		Central	Mwea Tibere					
	May-Aug	East	Garissa Ngau	Sep-Oct Feb-Mar	Late Mar - Aug	Late Oct - Feb	Dec & Apr	
	Varies	North	Mandera Turkwell	Sep-Oct Feb-Mar	Late Mar - Aug	Late Oct - Feb	Dec & Apr	
MILLET SORGHUM	Jan-Feb	Central	Machakos Kitui					Emergent Damage Machakos-Kitui Oct-Nov

Table 4. Quelea damage in Tanzania (DWRC 1974 Annual Report)

CROP	TIME	DAMAGE AREAS		WEATHER PATTERN			OTHER
		GENERAL	SPECIFIC	DRY	LONG RAINS	SHORT RAINS	
WHEAT	Jul-Sep	Northeast	Sungate Makuyuni	Jul-Nov Feb	Mar-Jun	Dec-Jan	Emergent Damage Sungate Makuyuni Mar-Apr
RICE	Jun-Sep	Northeast	Same				
	May-Jun	Northwest	Musoma Mwanza Shinyanga	May Oct	Nov Apr		
	Apr-Jun	Central	Rufigi Basin	Apr-Dec	Jan-Mar		
	Mar-Jun		Kilangali Kilosa Myomero				
	Mar-Jun	South	Mbeya Mbarali	May Jan	Feb Apr		Emergent Damage Mbarali Oct-Nov

Table 4 (continued

CROP	TIME	DAMAGE AREAS		WEATHER PATTERN			OTHER
		GENERAL	SPECIFIC	DRY	LONG RAINS	SHORT RAINS	
MILLET SORGHUM	Jun-Jul	Northwest	Mwanza Shinyanga				
	Mar-May	Central	Singida Dodoma Morogoro				

RESEARCH ACTIVITIES AT TPRI FOR THE EAST AFRICAN COMMUNITY

Four Laboratory Studies, 1975-1976, Arusha, Tanzania

Four laboratory studies were designed and begun at TPRI near the end of 1975. The results of this research were to have been reported by the TPRI Bird Pest Section staff by late fall of 1976 but were not completed. Results presented below are a partial summary from information compiled by TPRI personnel. Consequently, the conclusions are quite brief. The study plans are reported here verbatim so that the objectives of each study can be understood.

Load-lifting Capacity of *Quelea quelea*

Introduction

DWRC personnel have successfully instrumented several bird species for telemetry studies. They have never instrumented birds as small as quelea (average weight 16-18 g). This study was to determine the maximum capacity a quelea can carry and still fly normally. The data will be used by DWRC Supporting Sciences personnel to develop a transmitter unit for telemetry field studies.

Methods

a. Test Site

The tests were conducted in 3 m X 3 m X 1 m chicken wire mesh pens at TPRI.

b. Test Design

Dummy transmitters weighing 1.5 g, 2.0 g, 3.0 g, and 3.5 g were evaluated. Eight birds--four males and four females--were instrumented for each weight unit. The weights were attached with a fast-drying adhesive (Super Glue 3, Loctite Group, Cleveland, Ohio). Attachment was on the dorsal surface at the base of the tail feathers. Birds were weighed prior to being instrumented to evaluate what percentage of their body weight they could efficiently carry. Individual birds were identified by toe clipping.

c. Evaluation

The birds were released into the holding cages and individual flight patterns, designated as "flew easily", "flew with

difficulty", or "unable to fly" recorded. Durability of the attachment was measured by daily observations.

Results in 1976

Birds could carry dummy transmitters up to 2.5 g but the most reasonable weight seemed to be 1.5 g. Dummy transmitters weighing 1.5 g represent an average of 8.15% of total body weight.

Food Preference of *Quelea quelea*

Introduction

Controversy exists over what is the preferred food of quelea. Several investigators (Naude, 1955; Lourens, 1955; Ward, 1965) believe the principal food of quelea throughout Africa is the seed of wild grasses. Ward (1965) stated, from a study in Nigeria, that the birds would eat the seeds of over 40 species of grasses, but two-thirds of their annual diet was composed of the seeds from only 3 species (wild rice *Oryza barthii*, wild sorghum *Sorghum purpuree-castanoum*, and wild millet *Echinochola colonum*). In contrast to these observations, Mr. H. Doggett, one-time cereal breeder in East Africa, strongly believes quelea prefer white sorghum over any wild seed (personal communications with Maeda in 1972).

Even though food studies have been done with quelea, to the best of our knowledge a comparative food preference between cultivated crops and wild seeds has never been conducted. Thus, the main objective of this two-phased investigation is to determine if quelea actually do prefer a specific grain or seed as a food source. If there is a preferred food source, then the preferred grain or seed could be used as the carrier in bait formulations. This could enhance bait acceptance in the field. Another possible use of the findings is strip farming with the preferred grain or seed as a way to concentrate birds and damage to one part of the cultivated area.

Methods

a. Test Site

The tests were conducted in 3 m X 3 m X 1 m chicken wire mesh pens.

b. Test Design

Part I

Five cultivated crops were used in the test: white sorghum, wheat, intact rice with shell, bulrush millet, and finger

millet. The grain was made available in feeding trays with sloping sides: 18 cm X 18 cm on the bottom, 32 cm X 32 cm on the top with a height of 8.5 cm. This type of feeder design was chosen to eliminate spillage by the birds when feeding. Birds were given two-choice food preferences with the following combinations:

wheat/white sorghum
wheat/bulrush millet
wheat/rice
wheat/finger millet
bulrush millet/white sorghum
bulrush millet/rice
bulrush millet/finger millet
white sorghum/finger millet
rice/white sorghum
rice/finger millet

Five feeding stations were placed in each study pen. At each feeding station both grains were available (in trays placed side by side). Ten feeding trays were used (five with grain A and five with grain B). Water was available ad libitum by several spring-type water bottles positioned throughout the study pen. Twenty birds were used in each combination test (10 males and 10 females). Daily consumption volumes were to be recorded. Rice shells and wheat husks were recorded as consumed food. Each combination test lasted 6 days. Two combination tests were conducted simultaneously to reduce the time factor.

Part II

If one of the cultivated crops was preferred, then test two would be combination tests of the preferred cultivated crop and wild seeds. If the preferred cultivated crop was white sorghum, then the cultivated crop/wild seeds tests were preceded by a comparative test with the three available varieties of sorghum.

Locally available wild seed used were wild sorghum and wild millet. Combinations were:

preferred cultivated crop/wild sorghum
preferred cultivated crop/wild millet
wild millet/wild sorghum

The same experimental design as described in Part I was followed.

Results in 1976

Five cereals were compared to each other, and the order of preference by quelea was as follows:

1. Bulrush millet
2. Rice
3. Wheat
4. Sorghum
5. Finger millet

Breeding *Quelea quelea* in Captivity

Introduction

As far as we know, nobody has successfully bred quelea in captivity and compared this to the breeding in natural conditions. Most of the studies on the breeding behavior have been done in the field where it was not possible to follow the whole process as closely as one would like. The development of the offspring and the breeding potential of the breeding females have not been adequately documented. If quelea do breed in captivity, these studies will give us more detail in these aspects. These studies will also form a basis for future studies in the development of topically applied chemosterilants for quelea control.

Methods

The studies were conducted in an 11.7 m X 3 m X 3.8 m chicken wire aviary with a half roof (to provide shade when necessary) at TPRI. The aviary was provided with a number of acacia branches and materials which may be required for nest building. For the second part of the study, materials of different colors, texture, and sizes were provided in order to establish any bias in the nature of nest building materials. Food and water was provided *ad libitum*. Sixty pairs of birds were collected just before breeding started and placed in the aviary. The activities of the captive birds were followed very closely and special emphasis was placed on trying to compare the nesting and breeding activities to those in a typical natural condition. The study was to be carried on for 20 months.

Results in 1976

Although nest building was initiated, no successful breeding was recorded because:

1. Nesting material was not provided as required.

2. The aviary was built too near the workshop so the birds were always being disturbed.

Retention of Leg Streamers by *Quelea quelea*

Introduction

Leg streamers have been used in behavioral studies with many species of birds in the United States and Europe. Streamers have never been attached to quelea. It has been shown with blackbirds that color may directly influence retention of streamers (Royall et al., 1974). In laboratory studies with commercially available streamers (Saflag and Facilon), DWRC personnel found retention of rocket red streamers comparatively short, apparently because the blackbirds reacted to this color and pulled the streamers off. The main objectives of this study were to determine streamer retention and wear with quelea and whether color, as shown with blackbirds, influences retention with this species. Results will influence streamer selection.

Methods

a. Test Site

The test was conducted in a 3 m X 3 m X 1 m chicken wire mesh pen. The study pen had perches. Food and water was available *ad libitum*.

b. Test Design

Markers of each color were attached to 10 birds (5 males and 5 females) each. Colors used were:

Company	Color
Saflag	Rocket red Blaze orange Signal green White
Facilon	Red Yellow Blue

Attachment was as described by Guarino (1968). Due to the size of quelea, only a portion of the commercial streamer was attached. Ease of flight will determine which size to use.

Birds were inspected daily for streamer loss and monthly for streamer wear. Wear was evaluated as:

"None" - No more than one or two minor cracks in the plastic, no nylon threads frayed or broken.

"Slight" - Only minor cracks in plastic, few or no threads frayed or broken.

"Moderate" - Plastic cracked from attachment hole to outer edge, some threads broken but attachment to band secure.

"Severe" - Plastic badly broken, many threads broken, attachment insecure.

Data will be collected for 6 months.

Results in 1976

Most birds with streamers had either rotten or rotting legs. Several birds had their legs missing. This was because of both ring and streamer were tied to the legs and the band with streamer attached was too small.

	Males	Females
Total birds tagged with streamers	70	64
Birds found without streamers at completion of study	39	41

Other Laboratory and Field Studies, 1974-1976, Tanzania and Kenya

Questionnaire

Questionnaires were prepared by the TPRI Bird Pest Section staff in 1974 and 1975 for the purpose of gathering information on quelea breeding, roosting, population activity, and crop damage. Information collected was to provide the basis for planning field damage assessment studies, leading later to direct crop protection through chemical control with avicides. Lastly, TPRI field study data were to be combined with the questionnaire information about quelea distribution and damage activities in East Africa and then were to be compiled as a detailed map. Thus far, these data have not been reported by TPRI.

A viable vertebrate pest research and control program can collect certain basic pest data through questionnaires and follow-up field surveys. Above all, when the information has been collected and

confirmed for its accuracy, then it must be tabulated, plotted on maps or tables, and disseminated to other researchers experiencing similar or common vertebrate pest problems. Only when these basic research steps are taken in cooperation with a country's Ministry of Agriculture will it be possible to undertake crop damage assessment and crop protection studies.

Field Damage Assessments

Field damage assessments on cereal crops of the EAC were to be one of the DWRC biologist's primary objectives following his arrival at TPRI. The objectives, problems, and procedures for damage assessment were outlined as follows:

1. Objectives

   a. There is a need to evaluate and accurately assess damage caused by quelea and other species to cereal grain crops such as wheat, rice, sorghum, and millet.

   b. There are known assessment techniques, but these require alteration and modification for African conditions.

   c. Season, location, severity, and percent damage will be determined for each crop affected.

2. The Problem

   Small grains are damaged heavily by birds in many parts of the world in general and in Africa by quelea in particular. Estimates of yield and reduction in yield caused by birds have been frustrated by field heterogeneity, variability in size of heads, and difficulty of determining damage over large areas.

   To gauge the amount of research a problem warrants, it is necessary to have a general estimate on the extent of the problem and the amount of loss being sustained on unit areas (a group of farms, a county, a state). Loss information on national or worldwide scale enlists the greatest coordinated effort. As the cost-benefit ratio is the basis for determining the real value of any control method, loss data dictate the type of control sought and are the measure by which success or failure may be judged. A basic method for rapidly and reliably measuring bird damage to a given crop, even on a small test plot, is seldom available and usually has to be developed. Methods for appraising bird damage to such important crops as corn, rice, and grain sorghum have been, or are in various stages of development, and these methods will be investigated on African birds and crops.

3. Procedures

Assessment techniques will be developed in conjunction with actual field tests of various control studies. The technique employed will be dependent on the situation. Basically, the following procedures will be used:

a. After the field site has been designated, randomly select a statistically significant number of treated and control fields.

b. Randomly select a number (2 to 8) of plots within the field to be surveyed.

c. Select a uniform number (50 to 100) of heads for each sample plot.

d. Conduct damage surveys the day before bird damage is anticipated and at the end of the damage period.

e. Compare the number of damaged heads on the treated and control plots. Convert this figure to grams lost per plot and bushels lost per acre. Convert these figures to dollars lost per acre. Determine the cost per acre of control and compute a cost-benefit ratio.

f. For additional reliability, conduct pre- and post-population estimates at the study site to determine differences in bird feeding activity.

Earlier work by DWRC biologists in East Africa had determined that despite bird control measures at quelea roosts and nesting areas, serious losses of grain crops continued to occur in both Tanzania and Kenya.

Crops of East Africa most affected by quelea damage include sorghum, wheat, millet, and rice. Sorghum damage has been considered most serious in Tanzania, followed by millet, wheat, and rice. In Kenya, wheat is the crop most seriously affected by quelea, followed by sorghum, millet, and rice.

Areas in Tanzania annually sustaining the highest crop damage include the regions of Mbeya, Iringa, Dodoma, Singida, Arusha, and Kilimanjaro. In Kenya, the Central Zone extending from Nanyuki through Nyeri, Embu, Kitui, and Machakos; and the Western Zone centering around Nakuru, Eldoret, Kitale, and Kisumu, experience the highest grain losses. Famine reports were noted several times in 1976 from both countries in these heavily damaged areas. According to Mr. F. Kitonyo, Bird Control Officer, Kenya, quelea caused extreme wheat losses in the

summer of 1976 in the Nanyuki area. Sizable losses were also reported from western Kenya in its prime wheat- and rice-growing areas.

The Tanzania Daily News reported heavy losses to quelea in grain crops throughout 1976. In the November 3, 1976, issue of the Daily News, famine conditions were reported from Singida where an estimated 2,000 metric tons of millet had been taken by quelea.

Damage assessment studies proposed to TPRI for EAC by DWRC in 1976 are summarized in Table 5. As shown in Table 5, DWRC efforts to implement field damage assessments were unsuccessful during 1976. Surveys which were completed supported earlier damage assessments that quelea caused losses ranging from 30 to over 75%. Results of damage assessment studies for 1975 and 1976 are tabulated in TPRI unpublished Miscellaneous Report No. 933 by M. G. Ngala and W. H. Bohl.

Proposed Field Damage Assessment/Replicate Studies

In 1974, DWRC Biologist John W. De Grazio conducted experimental chemical control studies on certain grain crops in Tanzania and Kenya, results of which were reported in the DWRC 1974 Annual Report. With these chemical experiments the foundation was laid for the implementation of a vertebrate pest research and control program for East Africa.

Biologist Wayne H. Bohl presented damage assessment study plans for the Tanzanian government's Garagua Wheat Farm on the west slopes of Mt. Kilimanjaro. A similar replicate study plan was proposed for the Arusha Seed Farm, a cooperative foundation wheat project between the Government of Tanzania and USAID. Neither study was approved for the experimental use of the chemicals methiocarb or Avitrol, based on the view of the TPRI Bird Pest Section that chemical analyses and toxicological studies had not been completed. These laboratory tests were deemed mandatory by both DWRC and TPRI before chemicals could be utilized in experimental field tests.

Accordingly, the proposed field testing was postponed pending the procurement of pure samples of methiocarb and Avitrol for laboratory tests by the Chemistry Section and the Bird Pest Section of TPRI. These were presented to TPRI by DWRC and the Chemistry Section quickly completed their analytical studies of these chemicals. Through termination of the project on February 28, 1977, the Bird Pest Section had not completed its LD_{50} and R_{50} laboratory studies. Comparable tests had been completed at the DWRC laboratories in 1975 and early 1976 on quelea procured from Senegal.

Table 5. Damage assessment studies proposed for East African Community, Tanzania and Kenya, 1976

DATE	AREA TO ASSESS	CROP	REMARKS
Jun 6	Garagua Farm, West Kilimanjaro, Tanzania	Wheat	Survey conducted by TPRI field officer and assistant. Cancelled by TPRI pending completion of laboratory studies of methiocarb and Avitrol by Bird Pest Section staff
Jun 12	Arusha Seed Farm, Arusha, Tanzania	Foundation wheat - seed production	Field study cancelled by TPRI; same reason as above
Sep 21-Oct 2	Western Kenya--Nakuru, Kisumu, Ahero, Eldoret, Mwea	Wheat Rice	Part I, Damage Assessment Study for Kenya (see TPRI Misc. Rep. No. 933)
Oct 14	East African Community--Tanzania, Kenya	Wheat Sorghum Millet Rice Sunflower	Damage Assessment Study Plan presented to TPRI by DWRC: Damage Assessment EAC Oct 20-Dec 20; replicate studies for Jan 1-Dec 1977. Plan approved Nov 5, but entire work study plan cancelled same day by TPRI
Nov 20-Dec 15	Western Kenya--Machakos, Kitui, Embu, Nanyuki, Nyeri	Wheat Sorghum Millet	Part II, Damage Assessment Study for Kenya. Second trip cancelled by TPRI for reasons unstated

At the July 12 meeting between directors of TPRI and DWRC, long-range plans were proposed that would begin with damage assessments in Tanzania and Kenya on September 1 and last through December 15, 1976. Collection of these data would prepare the way for implementation of damage assessment/replicate studies in the EAC beginning shortly after January 1, 1977, and lasting through the year. These studies were contingent upon the Bird Pest Section completing laboratory studies on methiocarb and Avitrol. This lack effectively prevented the implementation of studies leading to direct crop protection.

Assessment of Kill Factor, *Quelea quelea* Control Operations

TPRI Miscellaneous Report No. 933 indicates that quelea suppression, particularly by chemical means, has been going on in several parts of Africa for over 25 years with little attempt to assess the effectiveness of these operations. The report notes that, "Proper kill assessment of control operations is very necessary, for not only does it determine the efficiency of one particular control operation but it also provides the basis for comparing and assessing different methods of quelea control using different chemicals."

The report concerns a suppression trial at Basotu, Tanzania, in May 1976. The quelea were feeding on wheat. The roost was sprayed with fenthion, 60% a.i., with kill assessment work conducted after spraying. Results indicated that the prespray roost population was estimated at 1.3 million birds; a postspray dead bird count indicated the percent kill was approximately 92%.

A guide was developed in this report to describe the kill success for quelea control operations. Further details of this report are available from TPRI or DWRC files.

Trapping *Quelea quelea* for Laboratory Research; Sexing Techniques and Food Habits Data

In August 1976, DWRC requested assistance from TPRI in trapping and shipping 200 quelea for laboratory studies on behavior, chemicals, and radio-transmitter development. Accordingly, trapping August 5 to 20 at Burka near Arusha resulted in the taking of 200 quelea for DWRC and an additional 250 birds for LD_{50} and R_{50} laboratory studies by the TPRI Bird Pest Section.

Between November 8 and 29, 1976, additional quelea were mist-netted at Burka for the purpose of utilizing 200 birds for field testing experiments with methiocarb and Avitrol.

Considerable other data were collected during the August and November trappings. These included sexing techniques, food habits, and other life history details, all of which are presented in the unpublished TPRI Miscellaneous Report No. 932.

Termination of USAID/DWRC Research Activities at TPRI

On January 18, 1977, staff biologists representing Dr. Nels Konnerup, USAID Vertebrate Pest Research and Control Project Leader, met at TRPI with Acting Director C. S. Tarimo and Biologist G. Maeda. The purpose of this meeting was to present a formal letter of termination from USAID/DWRC to TPRI, according to the terms of the Memorandum of Understanding. The letter further called for an agreement between TPRI and USAID/DWRC personnel on disposition of AID and DWRC property. These matters were satisfactorily settled by February 28, 1977.

Regret was expressed that the Bird Project at TPRI was not able to function to its fullest capacity for the EAC, however, it was deemed both necessary and desirable to terminate the project in a spirit of understanding. In terminating further vertebrate pest research at TPRI, the USAID/DWRC staff wished TPRI the best in its future endeavors.

Research on vertebrate pest damage problems in Africa will be continued by USAID/DWRC and it is hoped that the results of these findings may one day be beneficial to all of Africa.

DENVER WILDLIFE RESEARCH CENTER ACTIVITIES

Current Status and Future Goals - Africa

The primary objective of the Vertebrate Pest Research and Control Project in Africa has been to develop direct crop protection methods rather than concentrating only on population suppression. The USAID/DWRC program has worked in Africa since 1971 and the current status for 1976-1977 is as follows:

1. Field station established April 1976 in Tanzania for EAC to develop crop protection methods for the African weavers and other birds damaging small grains.

2. Station terminated February 1977 due to unforeseen difficulties; project to be transferred to Sudan Ministry of Agriculture May 1977.

3. Previous short-term research activities in Africa in 1971 through 1974 by DWRC have indicated repellents show potential in protecting crops.

4. Quarantine facilities have been established at DWRC for quelea imported from Africa for the following laboratory research priorities:

   a. Determining behavioral responses to chemical repellents.

   b. Developing radio-tracking techniques.

   c. Evaluating immunological, physiological, and topical marking agents.

   d. Developing baits to deliver uniform dosage in field applications.

   e. Breeding quelea in captivity.

   f. Determining energy requirements and digestion efficiency.

   g. Evaluating control by treated nest building materials.

   h. Screening of alternate chemical compounds.

   i. Measuring reaction to high frequency sound.

Future DWRC goals in Africa for research and control of quelea will be to continue laboratory and field research studies 1977 through 1981. Proposed field research studies will include:

1. Evaluation of chemical control

   Chemicals will be investigated for frightening, repelling, or killing quelea. The major field approach will be through baits and crop sprays. Known candidates are methiocarb and Avitrol.

2. Evaluation of baits and baiting techniques

   Baits and baiting techniques developed in the United States will be adapted to African conditions. Development of baits is essential to chemical control and will include comparison of particle size, concentration, placement, application, and timing.

3. Damage appraisal--methodology, extent and severity of loss

   Damage assessment techniques developed in the United States will be adapted to African conditions. Field studies will include evaluating damage patterns, alternate foods, sampling, and other variables of field data collection. Losses to small-grain crops will be documented in selected areas in terms of season, location, severity, and percent damage.

4. Survey of populations and movements

   Continuous information will be gathered on quelea concentrations, movements, and breeding and roosting locations in relation to damage areas by severity and season.

5. Evaluation of traps and trapping

   Techniques will be established for capturing quelea as an aid for determining movements in damage areas. This may include radio telemetry, banding, color marking, and antibody marking studies. Development of traps may also be useful for increasing the protein food supply of the poor since quelea are a common dietary item.

6. Evaluation of mechanical devices

   Only simple, economic devices will be evaluated. Mechanical devices developed must demonstrate low capital and operational costs for acceptance by small landowners.

USAID/DWRC Vertebrate Pest Research and Control operations will be transferred to Sudan in May 1977. Field research goals planned for Sudan are those outlined above.

RODENT RESEARCH CENTER - PHILIPPINES

PRINCIPAL INVESTIGATORS:

Fernando F. Sanchez, Jesus P. Sumangil, Edwin A. Benigno,
Melanda M. Hoque, Justiniano L. Libay, Bernardo E. Marges,
Pablo P. Ocampo, and Russell F. Reidinger

INTRODUCTION

The Rodent Research Center was established in June, 1968, as a joint undertaking of the Government of the Philippines (GOP) and the United States Agency for International Development (USAID). The GOP is represented at the Center by personnel from the Bureau of Plant Industry and the University of the Philippines at Los Baños (UPLB). Additional support and cooperation are furnished by the National Economic and Development Authority, the National Food and Agricultural Council, the National Science Development Board, the Philippine Council for Agricultural and Resources Research, and the Philippine Atomic Energy Commission. USAID is represented by personnel from the Denver Wildlife Research Center of the Department of Interior, U.S. Fish and Wildlife Service. The Center's activities are determined with the advice of a Board composed of a senior member of each of the cooperating agencies.

In May, 1976, the National Crop Protection Center (NCPC) was established on the campus of the UPLB by Presidential Decree No. 936. This Center, along with seven affiliated regional centers, will have primary responsibility for the research, development and dissemination of integrated crop protection systems for the country. At the first Advisory Board meeting of the NCPC, held in November, the Rodent Research Center was incorporated as a unit within the NCPC. Although the NCPC is still in the early stages of development, we look forward to this association as a positive step toward meeting the crop protection needs of the farmer.

Program and Facilities

The programs of the Rodent Research Center are aimed at the goal of reducing vertebrate damage to agricultural crops in the Philippines and other countries of Southeast Asia. To help achieve this goal, the overall program has emphasized not only adaptive research and control-methods evaluation, but also the development of a technical backstop capability to advise regional plant protection agencies and a training capability to encourage rapid use of new findings. During the year, backstop activities have included trouble-shooting visits to specific problem areas, species identifications, advice to agencies on the organization of damage evaluation surveys, control programs, and adaptive research plans, and limited data analysis for agencies involved in cooperative programs. Current research has become more directly focused on field evaluation of control methods on Philippine pest species, while training has assumed increasing importance at the Center.

Staff

The Center staff includes six biologists and two field technicians whose aggregate training covers the areas of agricultural biology, ecology, physiology, control methods evaluation, mammalogy, ornithology, wildlife management, biometrics and entomology. Eleven additional staff members are assigned as full-time support personnel by participating agencies. Mr. Thaddeus A. Obadoni, from Nigeria, spent almost 3 months as a participant staff member of the Center.

Mr. Danilo C. Sanchez, USAID technician, left the Center for a research assignment with CARE in March. Mr. Pablo P. Ocampo joined the Center as a USAID technician in April.

Research

In rice, a trial was conducted on the effectiveness of the sustained baiting program in protecting fields from losses to rats in one of the most difficult damage situations known to occur in the Philippines. Studies were continued on the operational characteristics of non-lethal electric barriers, and preliminary information was obtained on the movement patterns of rats in relation to rice culture. In coconut, a two year evaluation of the effectiveness of crown-baiting with chronic toxicants was completed, the effectiveness and costs of crown-baiting were compared with ground-baiting, the movement patterns of rats between tree crowns and the ground level was studied, and preliminary information was obtained on the relationship between rat damage and copra content of coconuts. In corn, a study was conducted on the effectiveness of a sustained baiting method in reducing rat damage, preliminary information was obtained on the reliability of three sampling methods in estimating rat damage and on the use of area of damage on individual ears as a parameter for predicting corn loss (weight) to rats.

The acute oral toxicity of warfarin to local, domestic chickens was also determined, and studies were continued on toxicity and repellency of several chemicals to Philippine pest bird species. Studies were continued on the biology and damage behavior of several bird species.

Training

Training activities were aimed toward up-dating the knowledge of vertebrate pest control of extension technicians, and to a more limited extent, toward providing experience in the research methodology for professional vertebrate biologists in the Philippines and other countries of Southeast Asia. Again, several hundred visitors from many countries were briefed on Center activities, or given assistance in planning rodent control or research programs. Center staff members participated in the training of more than 3000 agricultural extension personnel from the Bureau of Plant Industry, Bureau of Agricultural Extension, Philippine

National Bank, Agricultural Credit Administration, National Food and Agricultural Council, and other agencies. Sessions on rat control were presented in agricultural production workshops held at IRRI and UPLB. One research trainee from Nigeria spent almost three months at the Center participating in a variety of on-going research programs and working independently on a project proposal for presentation to his parent organization. Three staff continued their pursuit of Ph.D. degrees, one under a PCARR grant, the others with UPLB's reduced fee privilege. Six additional students, who are working for their M.S. degrees and one for his Ph.D. at the UPLB, completed their formal coursework and began their thesis research projects at the Center. Several staff members taught or participated in teaching courses in Vertebrate Pests, Experimental Design, and Wildlife Management at UPLB, while others served as graduate advisers for studies in Applied Zoology.

International Activities

The Center Director was nominated as the invitational speaker for the 1976 Annual Meeting of the Entomological Society of America, held in Honolulu, Hawaii, in November-December. In his keynote address, Director Sanchez summarized the current status of rice pest management in the Philippines. He later attended a conference, co-sponsored by the East-West Food Institute and the University of Hawaii, on the Impact of Pesticide Laws. Earlier in the year he had attended a conference in Hawaii on the Consolidation of Crop Protection Courses and presented a paper on the training needed by the pest management specialist.

SUMMARY OF ACCOMPLISHMENTS

1. Full or part-time Center staff included five biologists, nine students, one biometrician, two field technicians, one trainee from Nigeria and eleven supporting staff.

2. A baiting program using anticoagulants to protect coconuts from rat damage was evaluated for two years in Mindoro Oriental where R. r. mindanensis, R. argentiventer, R. exulans, and S. murinus are found. Four plots, each one hectare with one hundred trees and separated by at least 200 meters, were chosen: during the first year, two plots were randomly selected for treatment and two designated as reference plots; during the second year, all plots were treated. During periods of treatment, a single packet of poisoned bait was placed in the fronds of twenty-five randomly selected trees per plot each month. By the third month after treatment, rat activity and numbers of fallen nuts had dropped to negligible levels in each of the plots and remained low thereafter, while rat activity and numbers of damaged nuts had remained high in reference plots during their one year without treatment. Production in the plots, during periods of treatment, increased about 2.5 times over pretreatment levels. Cost/benefit, based on actual costs for control and copra production, averaged 1/24. We concluded that sustained crown baiting has the potential of providing long-term reduction of coconut damage by rats.

3. A study was conducted in two, one hectare coconut plots (separated by 300 meters) to determine relative species composition and movement of rodents between tree crowns and the ground level. In one plot (A), packets containing polished rice and tetracycline hydrochloride (TC; a marking agent) were placed in the crowns of 50 randomly selected trees. In the other plot (B), the packets were placed at the ground level. After one week, packets were retrieved, the amount of bait consumed was determined, and trapping was conducted for three consecutive nights (at ground level in Plot A, at crown level in Plot B). Rats caught were identified and checked for presence of the marking agent. In Plot A, R. r. mindanensis, R. exulans and R. argentiventer were captured, but only R. r. mindanensis and R. exulans were marked; in Plot B, only R. r. mindanensis and R. exulans were taken and both species were marked). Bait consumption and trap success were lower in tree crowns than at the ground level.

Based on these results, we suggest that R. r. mindanensis and R. exulans moved actively between tree crowns and the ground level, but that relatively fewer individuals inhabited the tree crowns, and that movement of R. argentiventer from the ground level to the tree canopy was either severely restricted or absent.

4. Ground-baiting and crown-baiting were compared for relative effectiveness and economic benefit in a five hectare coconut plantation near Victoria, Mindoro Oriental. During the first 13 months of the study, bait stations containing anticoagulant rodenticices were placed near piles of litter at the ground level; during the next 12 months, one-fifth of the trees in the plantation were crown-baited monthly with packets containing anticoagulant rodenticides. Monthly records were maintained of the amounts of bait used, rat activity, and numbers of fallen nuts, and numbers of nuts harvested were recorded for each harvest period. Rat activity and numbers of fallen nuts were reduced by both methods, but were lower during the period of crown-baiting. More bait was used for the ground-baiting than the crown-baiting method (6 vs 1.5 kg per hectare per month, respectively), and more labor was required to maintain the baiting program (about 20 vs 12 hours/month, respectively). During a 22 month period prior to the study, coconut production averaged 2.9 nuts per tree per month; during the period of ground baiting, 5.8 nuts per tree per month; and, during the period of crown-baiting, 7.2 nuts per tree per month. We concluded that both ground-baiting and crown-baiting reduced rat activity and damage at our study site, but that crown-baiting was more effective and cost less, perhaps because it is more selective in reaching target organisms.

5. To determine if coconut trees can compensate for rat damage, we compared the sizes, weights, and copra contents of individual nuts (60, randomly selected during a single harvest) from an area which had received effective rodent control for twenty-one months with nuts (60, randomly selected during a single harvest) taken from an adjacent area which had no rodent control program and which was suffering from heavy rat damage. Wet weight of flesh averaged 0.86 kg per nut in the treated area, 0.050 kg (5.5%) less than in the area which had received no rat control. Likewise, dry weight of flesh (copra) in the treated area averaged 0.37 kg per nut, or 0.038 kg (9.4%) less than in the untreated area. When compared with larger samples taken over a longer period of time, however, differences were greatly reduced. We concluded that partial compensation by trees for heavy rat damage may have occurred in our experimental plots, but, if present, the amount of compensation was slight, insufficient for obvious separation from the fluctuation

of copra content over extended periods of measurement, and inadequate to decrease significantly the economic benefits which were gained by following the baiting programs.

6. The movements of rats in relation to rice culture were followed in a 1900 hectare ricefield area near San Antonio, Nueva Ecija, where planting and harvesting during the wet season follows recession of floodwaters. Bait stations containing polished rice with TC were placed in the first-planted fields at the vegetative stage, and trapping was conducted monthly in ricefields at vegetative to post-harvest stage for the next eleven months. Animals captured were examined for presence of the marking agent. In general, rats appeared to move in a directional manner out of harvested fields and into younger fields as the growing season for the study site progressed. This pattern was most apparent with adult rats, males moving the greatest distances -- two marked adult male rats were recaptured at least 1400 meters from the bait stations and as long as seven months after exposure to TC.

7. The effectiveness of the sustained baiting method was tested in protecting 100 hectares of ricefields adjacent to marshes bordering the Chico River near San Antonio, Nueva Ecija (the last 100 of 1900 hectares to be harvested in the area, see # 6 above). Baiting followed closely the interagency recommendations for Masagana-99. Monthly records were maintained on the amounts of bait used, numbers of bait stations, and rat activity (by using tracking tiles and records of trap success). Damage appraisal was conducted within two weeks of harvest and compared with adjacent areas where farmers used traditional control methods, and harvest records were obtained from the farmers. Bait consumption increased rapidly during the first nine weeks of baiting, then decreased rapidly as more rats contacted and were affected by the bait. Rat activity (as measured by both tracking tiles and trap success) dropped dramatically by the second month of baiting and remained low thereafter. Despite intense rat pressure, cost for control was estimated at less than ₱50 per hectare. Farmers in the treated area averaged 6.0% tillers cut while damage in adjacent fields was 70% or more. Although most of the harvest in the treated field was lost to flooding (caused by Typhoon Didang), yields in fields that were harvested averaged 75 cavans per hectare. In contrast, most farmers in adjacent fields reported complete loss of their crops to rats. We concluded that the sustained baiting program effectively protected the one hundred hectare baiting site (which was the last to be harvested, was adjacent to marshland, and represented one of the most severe situations for protection from damage that is encountered in Philippine ricefields) from serious rat damage, at low cost, and with potentially high economic return.

Previously plagued by chronic and severe damage, this farmer has lost only negligible amounts of rice to rats since he began using the sustained baiting program in early 1974.

8. To compare the operational characteristics of a non-lethal electric barrier with those of a lethal one, we conducted a small scale field trial with the cooperation of the International Rice Research Institute (IRRI). Six plots, about one-quarter hectare each, were provided for the study. Plots were paired, one lethal barrier and one non-lethal barrier, in three different areas along the periphery of IRRI experimental fields. Temperature, relative humidity and voltage of the non-lethal barriers were recorded daily from 10-13 weeks after transplant (WAT). In addition, tracking tiles were used to measure rat activity inside and outside each of the fences at the vegetative, booting and maturing stages of development, and damage appraisal was conducted for each plot within two weeks of harvest. Voltage of the non-lethal fence did not correlate well with either temperature or relative humidity. Batteries used to operate the lethal fences were recharged daily; those used to operate the non-lethal fences were recharged up to two times during the two-month period of study. Rat activity increased during the growing season, and was significantly greater outside than inside the barriers, indicating that both fences afforded some degree of protection. Rat activity was greater, however, within plots surrounded by lethal barriers than non-lethal barriers, average 5% vs 1% respectively. Damage in plots surrounded by lethal barriers averaged 2.05%; those surrounded by non-lethal barriers averaged 0.23% tillers cut. We concluded that the non-lethal barriers provided comparable or better protection from rat damage than the lethal barriers without the need for a night crew to remove electrocuted animals and without the need for daily battery recharges.

9. To determine the potential hazard of warfarin to local domestic chickens (Gallus gallus), we conducted two successive tests in which 33 day old broiler chicks were exposed (by gavage) in groups of four to the following concentrations of warfarin: for the first test, 0, 25, 125, and 470 mg per kg body weight; for the second test, 0, 625, 705, and 1057 mg per kg body weight. Animals were observed for fourteen days after gavage. Four of the fowl died during the period of observation (one each at 0, 470, 625, and 705 mg per kg body weight), but only two of these had symptoms of anticoagulant poisoning (one at 470 and one at 705 mg per kg body weight). We concluded that use of warfarin as recommended for reduction of rat damage to rice in the Philippines represents an extremely low hazard to domestic chickens by accidental poisoning, providing the farmer follows the recommended baiting program and does not allow his fowl to eat treated bait as a substitute food source for extended periods of time.

10. A baiting program using anticoagulants was evaluated on six, two-hectare corn plots in an area where R. r. mindanensis, R. argentiventer, R. exulans, and S. murinus were found. Three plots were randomly selected for treatment, three as reference plots. For treatment, we employed the continuous use of chronic toxicants at three baiting points per hectare, starting on the sixth week after planting. Stations were refilled two-three times weekly and adjusted to maintain a slight excess over consumption. In reference plots, rat activity remained about the same as the cropping season progressed, while it decreased rapidly in the treated plots. There was about an 84% reduction of damage in the treated plots. Cost of control was estimated at about ₱30 per hectare and yields in treated plots were about 4.4 cavans per hectare greater than in reference plots. Cost/benefit was estimated at about 1/7. We concluded that sustained baiting with anticoagulants effectively reduced damge in the treated corn plots, with apparently fair economic return.

11. Distributional maps of rat damage in cornfields were used as models on which to simulate potential sampling methods. Maps of damage were obtained for two cornfields, one 0.15 hectare with 15.04% damaged hills and one 0.35 hectare with 4.85% damaged hills. Three sampling methods (random, systematic, and random-clumped) were tested five times each on the maps. The systematic method had the lowest variability but the random method appeared most accurate. We concluded that additional studies are required to determine which methods will provide the best results with the lest effort in the field, but that the use of distributional maps as models for testing sampling methods provided a relatively quick and sensitive means of comparing the reliability of the methods.

12. The relationship between kernel weight and area occuppied on ears of corn was investigated to determine if it might serve as the basis for a simple, reliable means of predicting corn loss to rat damage. Sample ears (40) of mature, field-dried corn of various sizes were randomly picked at harvest from ears having rat damage in a seven hectare cornfield. Carbon paper and tracing paper were used to obtain impressions of the areas damaged and not-damaged on each ear and profiles of these areas was transferred to graph paper. Greatest length (with kernels) of the ear, length and width of damage, and weight of undamaged kernels were obtained for each ear. Area of damaged and undamaged portions of each ear were obtained by using a polar compensating planimeter. The sample included ears with about a threefold variation in size and a wide range of damage. The area of undamaged corn and its weight was highly correlated ($r = 0.96$, $P \ll 0.001$) with a single linear equation. We concluded that this relationship may serve as a means of predicting corn loss, and that additional studies are warranted.

13. In a trial on the use of methyl carbamate and fenthion as bird repellents, six small plots were located within a two hectare ricefield at three weeks before harvest: two were sprayed with methyl carbamate (4.7 kg active ingredient per hectare); two were sprayed with fenthion (0.9 gallon containing 50% emulsifiable concentrate per hectare); and, two were left untreated. Plots treated with methyl carbamate and fenthion averaged 6.5% and 7.0% damaged hills respectively, while the two untreated plots averaged 22% damaged hills. We concluded that both compounds hold promise as repellents, but that larger, more detailed studies are required to verify results.

14. Observations of bird damage were made on small plots of rice at hard dough stage. Damage was significantly greater along the shorter edges (widths) of the plots than along the other edges and inside the plots, but additional studies are required to see if this preference occurs in larger fields. In a study site in Mindoro Oriental, Lonchura malacca nested in calamansi (citrus) trees from February through May and from July through October and young were observed in March and April and August through October (trees were pruned in September and no nests were observed). This indicated a bimodal breeding season for L. malacca at the study site. In an acute oral toxicity trial, methamidophos was more toxic than carbofuran to L. punctulata, but considerably less toxic than carbofuran to L. leucogaster, L. malacca, and Passer montanus.

15. Over three hundred visitors from many countries were briefed on Center activities, given technical assistance in the form of literature on rodent control, or advice on program planning. Over 200 requests for technical information on rodent control were filled with Center publications, and others with copies of appropriate materials from bibliographic files.

16. Center staff members participated in the training of over 3000 government extension personnel and key farmers in vertebrate pest management methodology, and others in research methodology for vertebrate pest management. Trainees represented a variety of governmental agencies, including the Bureau of Plant Industry, the Bureau of Agricultural Extension, Philippine National Bank, Agricultural Credit Administration, Agricultural Credit and Cooperative Institute, Farm Systems and Development Corporation, National Food and Agricultural Council, and Philippine Sugar Institute.

17. One research trainee from Nigeria spent almost three months participating in a variety of on-going research and methods evaluation studies and worked independently on a project proposal related to vertebrate pest problems in Nigeria.

Arriving in flocks during the early milk to maturing stages, pest birds sometimes cause extensive damage to ricefields in the Philippines.

18. Staff members taught or helped teach courses in Vertebrate Pests, Experimental Design, and Wildlife Management at the University of the Philippines at Los Banos, with several classes and laboratories held at the Center.

19. The Government of the Philippines encouraged the use of sustained baiting with anticoagulants in ricefields through its national rice production program, Masagana-99, and its national rat control programs for non-Masagana-99 areas. Implementation of the rat control aspects of these programs was initiated through intensive training of extension officers, and, education of farmers in current methods involving use of acute toxicants and mechanical control to reduce population levels, then use of the sustained baiting program for long-term damage reduction. Preliminary surveys in target areas indicated that farmers who followed these recommendations were able to successfully protect their crops from serious rat damage.

20. Director Sanchez was nominated as the invitational speaker for the 1976 Annual Meeting of the Entomological Society of America, held in Honolulu, Hawaii, in November-December. In his keynote address, Dr. Sanchez summarized the current status of rice pest management in the Philippines. He later attended a conference, co-sponsored by the East-West Food Institute and the University of Hawaii, on the Impact of Pesticide Laws. Earlier in the year he had attended a conference in Hawaii on the Consolidation of Crop Protection Courses and presented a paper on the training needed by the pest management specialist.

21. In its third year of operation, the library now contains 716 books and pamphlets, 66 center publications, 872 reprints, 57 periodicals with a total of 1019 volumes, 94 maps and over 700 photographs. Newly established functions of the library include periodic literature searches, development of bibliographies, and distribution of content lists for journals that publish articles on vertebrate biology and control.

VAMPIRE BAT CONTROL IN LATIN AMERICA

PRINCIPAL INVESTIGATORS:

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ABSTRACT

The two vampire bat control methods are being evaluated in southern Bolivia. The study is being conducted to determine which method is most effective in areas with abundant wildlife.

"The use of Diphenadione (2-Diphenylacetyl-1,3-indandione) for vampire control in endemic rabies areas, northeastern Brazil" was the title of a thesis completed this year. In the study area, the vampire bat population was reduced 99.4% after control was applied.

A study was initiated in Nicaragua to determine the recovery rates of vampire bat populations after reductional control. Two years after control, the vampire populations remained low.

Campaigns for controlling vampire bats are reviewed in 10 Latin American countries.

An international symposium on vampire bat control was held in Managua, Nicaragua.

Eight manuscripts were published or are in press.

INTRODUCTION

Annual bovine losses resulting from vampire bat-transmitted rabies are estimated at approximately 1,000,000 head in Latin America. Daily loss of blood, mortality of other livestock, and secondary infections further aggravate the problem.

The original objective of research under this work unit was to develop techniques for controlling vampire bats. The project began in June 1968 and was funded by the Agency for International Development (AID) and the Mexican Government under a Participating Agency Service Agreement with the U.S. Fish and Wildlife Service (FWS), and the Instituto Nacional de Investigaciones Pecuarias (INIP). Laboratory and field investigations were conducted at the FWS Vampire Bat Research Station located in the INIP in Mexico City, Mexico. The station officially closed in December 1973, after species-specific control methods were developed.

In 1974, AID continued to fund this program with the objective that Denver Center biologists would help Latin American countries develop and initiate control campaigns through training and technical assistance.

VAMPIRE BAT CONTROL METHODS

Methods for reducing vampire bat populations developed by this project are described in the 1971 and 1972 Annual Reports and in several scientific journals.

Topically Treated Vampire Bats with Diphenadione

Vampire bats are captured with mist nets that are set around corralled cattle or at cave entrances. Approximately 1.5 cc of a petroleum jelly-Diphenadione mixture is placed on the dorsal surface of each captured bat and the bat is released. The bats return to their roost, and because they live in compact colonies, physically pass the chemical from one to another. The bats die after ingesting the chemical during grooming (Linhart et al., 1972).

Systemically Treating Cattle with Diphenadione

Cattle are injected (intraruminal) with 1.0 mg of Diphenadione per kilogram of body weight. The drug is absorbed and circulates in the blood. Any vampire bat that feeds from a properly treated animal, within 72 hours after treatment, receives a lethal dose of the drug. Treating all the cattle in a herd gives 90-95% reduction in fresh biting (Thompson et al., 1972).

RESEARCH ACTIVITIES

Evaluation of the Two Control Methods in the Province of Hernando Siles, Chuquisaca, Bolivia

Introduction

In Mexico, the United Nations did a food preference study on vampire bats and found the majority of the sample fed exclusively on bovine blood. This would be expected in Mexico where wildlife populations are low.

In parts of the geographical range of the vampire bat, wildlife is abundant. Theoretically, vampires could feed on wildlife, thus reducing the effectiveness of the control methods. Dr. Jorge Saucedo B. of the Committee for the Development of Chuquisaca will test this hypothesis. The objective of his field test is to determine if both control methods are equally effective under these conditions. The Committee will use the results to determine which control method to use in future work.

Procedure

The evaluation will take place in portions of a narrow valley 75 miles long located between the Parapeti River and the Pilcomayo River. Dr. Saucedo divided the valley into six zones. Each zone contained 12.5 miles.

Listed in Table 1 are data relative to the number of domestic animals in each zone and the history of vampire bat control and rabies in the area. The evaluation will take place in zones 4, 5, and 6. In Zone 4, the topical control method will be applied. Zone 5 is the control and cattle will be treated in Zone 6. Dr. Saucedo began the study in December. He plans to evaluate the study at 1-, 6-, and 12-month intervals.

The Use of Diphenadione (2-Diphenylacetyl-1,3-indandione) for Vampire Bat Control in Endemic Rabies Areas, Northeastern Brazil

Dr. Rogerio Piccinini is completing his thesis entitled, "The use of Diphenadione (2-Diphenylacetyl-1,3-indandione) for vampire bat control in endemic rabies areas, northeastern Brazil." The study area was 500 km^2 with 219 farms. In addition to controlling the bat population, deaths from rabies in the study area dropped from 140 cases for the 2-year period prior to control to 2 cases for the 2-year period following control.

Table 1. Livestock numbers and the history of rabies in the 75-mile area between the Parapeti River and the Pilcomayo River, Chuquisaca, Bolivia; each zone is 12.5 miles

Zone	No. Of Ranches	Total No. Of Animals						Rabies Outbreaks		
		Cattle	Sheep	Goats	Pigs	Chickens	Horses	1974	1975	1976
1	12	1,128	280	830	918	795	107	1	1	-
2	8	1,540	465	1,190	1,260	1,310	146	-	1	-
3	29	1,061	390	1,070	523	595	131	-	-	-
4	21	1,419	410	1,475	510	840	107	-	1	-
5	21	2,385	520	1,590	930	877	120	-	-	-
6	6	1,156	5	60	190	120	34	-	-	1
Total	97	8,689	2,070	6,215	4,331	4,537	645	1	3	1

Following is the abstract of Dr. Piccinini's thesis from the University of California, Davis.

"Abstract. Vampire bat control using Diphenadione (2-Diphenylacetyl-1,3-indandione, an anticoagulant) was applied in endemic rabies areas (Pernambuco and Algoas States) in northeastern Brazil. Analyses using the field collected data were carried out showing that the estimated number of vampire bats living in the area was reduced by 99.4% two years after the control had been applied. The best single method was the systemic treatment of cattle, but its combination with topical treatment of vampire bats was better than the first alone. A statistically significant decrease in the number of rabies cases in livestock was observed in the two years following control. A regression model to predict the number of vampire bats that will be caught on a given farm is presented as a tool for control methods. Also an optional method of treating with the paste fresh bites on suckling calves and cows in their late gestational period was used with good results. Recommendations are made to establish a Federal Pest Control Research Center in Brazil to study and solve economic problems in the agriculture and animal sectors such as vampire bat predation and disease transmission."

Recovery of Vampire Bat Populations After Control

The study was designed to measure how fast vampire bat populations recover after being reduced by control measures. The time necessary for vampire bats to reestablish sizable populations in control areas will determine how frequent control needs to be repeated.

Procedure

This study was initiated in 1971 and more details were presented in annual reports from following years. The basic procedure was to count fresh bites on cattle and apply control methods. Postcontrol censusing was based on fresh vampire bat bites on the same cattle. The original work was conducted on two ranches in northeastern Brazil. This year, the study was moved to Nicaragua with a sample of 90 ranches.

Results and Discussion

The study area is located in the Department of Granada, Nicaragua. Table 2 presents pre- and post-treatment bite counts on cattle in the region. One month after treatment, the bat population was reduced 88%, and 2 years after control the population was 92% less than prior to treatment. While statistical analyses of these data have not been completed, there is no reason to expect biological significance in the increased percent reduction in biting after 2 years.

Table 2. Effect of vampire control program on 90 ranches in the Department of Granada, Nicaragua

	Animals Examined	Fresh Bites	Bites Per 1,000 Animals	Percent Reductions From Pretreatment
Pretreatment Survey	7,644	7,354	962	-
One Month Posttreatment	7,426	853	115	88
Two Years Posttreatment	9,898	750	76	92

RESEARCH UTILIZATION

Belize

Education is part of the control program in Belize. Mr. Timothy McCarthy, Peace Corps volunteer, has been in charge of vampire control and recently prepared the following release for distribution prior to showing the film "Strange Creatures Of The Night."

"The BELIZEAN BAT REVIEW of the VAMPIRE BAT EDUCATION AND CONTROL PROGRAM, Ministry of Agriculture, cordially invites you to view the National Geographic documentary, "STRANGE CREATURES OF THE NIGHT."

"The Vampire Bat Education and Control Program is specifically concerned with the control of vampire bats where they are feeding heavily on the blood of livestock in Belize. The Belizean Bat Review is an important element as our educational extension. Our communication goals lay in two general areas. First, to create a greater communication with Belizeans about bats as one natural phenomenon in Belize. We need to place the bats in a proper perspective of importance. Second, to present a practical understanding of vampire bat biology and establish an importance for discriminately controlling only vampire bats. Proper education will lead to proper communication and participation by all Belizeans concerned.

"This film is a graphic explanation of how different living creatures live within the confines of darkness in comparison to man's inability. Since man cannot maneuver in the dark unaided, his understanding of the animals of natural darkness has been shrouded in fear, myth, and superstition.

"This movie exhibits explanations for previously not well understood actions or appearances of some creatures of darkness. You will experience a panorama of animals including a visitation to an owl's nest, the investigation of the invertebrates, fish and salamanders in a cave, observation of deep ocean creatures and the discussion of the relationships of the spotted hyena in Tanzania, Africa.

"The section on bats best relates to Belize because the majority of the represented bats live here. You will find this to be a visual and auditory experience which will answer many questions about BATS.

"Sit back and enjoy a visit to Bracken Cave (Texas) where millions of female Mexican free-tail bats come, for part of the

year, to have their young. These bats probably consume four billion insects per night.

"Listen and watch as scientists show that bats are not blind and emit high frequency sound that bounces back off objects as echos, a system called echolocation.

"Learn that it is because of superstition, fear and prejudice that we fail to realize that bats are important animals, feeding on different foods: insects, scorpions, fruit, nectar and pollen, fish, mice, rats, birds, lizards, other bats or blood.

"See Noctilio, the fishing bat, search and capture fish. This bat is found in Belize.

"Discover how an insect-feeding bat captures its food. Insect bats are the most abundant kind of bat in Belize.

"Learn about the common vampire bat, Desmodus rotundus. The only bat in Belize that feeds on the blood of cattle, horses, pigs, chickens, and people. Realize that this is a living creature that requires blood for life and not a medieval monster.

"See how bats have helped the disabled blind person 'see'.

"The Ministry of Agriculture wishes to thank the Denver Wildlife Research Unit, U.S. Department of the Interior, for the loan of this film.

"Protect the BATS OF BELIZE.
An important natural resource:
dispersers of seeds, pollinators
of flowers and major controllers
of crop-damaging insects."

Mr. McCarthy has shown the film to over 3,500 students in Belize City and plans further showings in six other cities.

The Ministry of Agriculture has assigned Mr. Matildo Valentine full time to vampire bat control. This means the program will continue to exist after Mr. McCarthy finishes his tour.

Mexican veterinarians from Quintana Roo learned of the control program in Belize. They have requested assistance to develop a control program and Mr. McCarthy or Mr. Valentine plan to visit Quintana Roo next year.

Brazil

Vampire bats are the principal source of bovine rabies in Brazil. At the same time that vaccination of cattle is made to control the disease, the vector is controlled by using the anticoagulant Diphenadione by rabies control teams. The activities of each team are coordinated by the field director who determines the priority areas for vampire bat control and vaccinating programs.

Following are the criteria considered for the control of vampire bats in Brazil.

1. Areas where rabies is endemic.
2. Areas with no rabies, but have a large vampire bat population.
3. Zones where vampire bat roosts have been found.

Vampire bat control is part of the National Animal Health Program dealing with foot-and-mouth disease, rabies, and brucellosis. Activities of the vampire bat control segment of this program from 1973 through 1976 are presented in Table 3.

Control has been applied in 13 states in Brazil. The control measures applied are as follows:

1. Vampire bats are captured around corrals and treated with Diphenadione.
2. Vampire bats are captured in caves and treated.
3. Occasionally, when cattle are heavily bitten the systemic control method is applied.

When applying number 1, biting was reduced an average of 90%.

A study was conducted in Santa Catarina to determine what percentage of a cave population should be treated for effective control. Three caves were selected, each containing a colony of approximately 60 vampire bats (Table 4). One vampire was captured in each cave, treated with Diphenadione and released. The number of vampire bats killed by Diphenadione intoxication for the three caves was 27, 29, and 42, respectively. Based on this study, when treating in caves, one vampire is treated for every 20 bats.

Brazilians have controlled vampires in 3,062 caves (Table 3). They have never found a nonhematophagous bat killed by the topical method.

Training. In 1973, Denver Wildlife Research Center personnel assisted Brazilians with two training seminars on vampire bat control. Following this, Brazilians conducted additional training programs in five regions of Brazil. A total of 125 veterinarians from 19 states have been trained (Table 5).

Table 3. Vampire control in Brazil, 1973-1976

States	No. Roosts Located				No. Vampires Captured And Treated			
	1973	1974	1975	1976	1973	1974	1975	1976
Piauí	-	-	-	-	-	-	-	647
Ceará	-	-	-	-	-	-	-	318
R.G. Norte	-	-	-	33	-	-	-	786
Pernambuco	-	3	-	-	-	343	-	-
Alagoas	-	8	7	29	-	770	111	334
Sergipe	-	-	-	6	-	-	-	260
Bahia	-	6	-	113	-	177	-	770
M. Gerais	11	24	-	-	4,312	-	-	-
Espírito Santo	-	-	-	55	75	-	-	226
R. Janeiro	164	17	3	-	659	52	-	-
Paraná	-	12	1	-	-	408	165	783
S. Catarina	-	2	-	31	-	824	-	671
R.G. Sul	911	860	-	766	-	-	-	-
Total	1,086	932	11	1,033	5,046	2,574	276	4,795

NOTE: The activities diminished considerably during 1975 because of a program implemented for the Diagnosis of the Animal Health Status, in which 1,022 veterinarians participated.

Table 4. Evaluation of control method through use of topical Diphenadione on vampires captured at the roosts, Santa Catarina, Brazil, 1974

Municipality	No. Roosts (Caves)	Approx. No. Vampires	No. Treated	Evaluation No. Days Posttreatment	No. Dead Vampires Collected
Sombrio	1	60	1	12	27
Sombrio	1	60	1	12	29
P. Grande	1	60	1	12	42

Table 5. Training courses on vampire bat control and the number of veterinarians that have participated from each state, Brazil, 1973-1976

Year	Course Locality	No. Of Participants Per State																			Total
		RR	MA	PI	CE	RN	PB	PE	AL	SE	BA	MG	ES	RJ	MT	GO	SP	PR	SC	RS	
1973	PE	-	2	2	2	-	2	8	3	-	-	-	-	-	-	-	-	3	-	-	22
	BA	-	-	-	-	-	-	-	-	-	14	-	-	-	-	-	-	-	-	-	14
	RJ	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	4	1	13
1974	RS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	11
1975	SC	1	1	1	-	2	-	-	-	-	-	2	2	-	2	2	2	2	14	2	33
1976	BA	-	-	-	-	-	-	-	-	2	6	2	2	3	2	1	-	-	-	-	18
	CE	-	1	2	8	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	14
Total		1	4	5	10	4	2	9	3	2	20	4	4	11	4	3	2	5	18	14	125

NOTE: Only 20% of these trained veterinarians worked specifically in rabies control; the others worked in rabies control and other diseases.

Colombia

The Ministry of Agriculture held a seminar on rabies at Chigorodo in October. Subjects discussed included: human rabies, bovine rabies, the biology and ecology of bats, and vampire bat control. Twenty-seven veterinarians and agronomists attended the seminar.

Dr. Jaime Cadena coordinates the national vampire control program. In November, he helped initiate a regional control program near Santa Marta. During 1976, approximately 200 cattle died from vampire bat-transmitted rabies in this zone.

Tentatively another training seminar is scheduled early next year at Santa Marta, Colombia.

Rabies outbreak occurred in eight states during 1976 (see Map 1). The Ministry plans to intensify control in these states during 1977.

Ecuador

The control program in Ecuador is being funded by the Centro Agricola of Quito and administered by the Ministry of Agriculture. At this time, the work is centered near Quito where vampire bats are possible vectors of anaplasmosis.

In November, 12 herds were treated systemically in the Tambillo Valley (Fig. 1). This is an isolated highland valley containing 1,408 dairy cattle. Prior to treatment, 519 fresh vampire bat bites were observed on the herds. Thirty days after treatment the biting was reduced 90%.

The Centro Agricola plans to fund additional control work in the Pifo and Los Chillos Valleys.

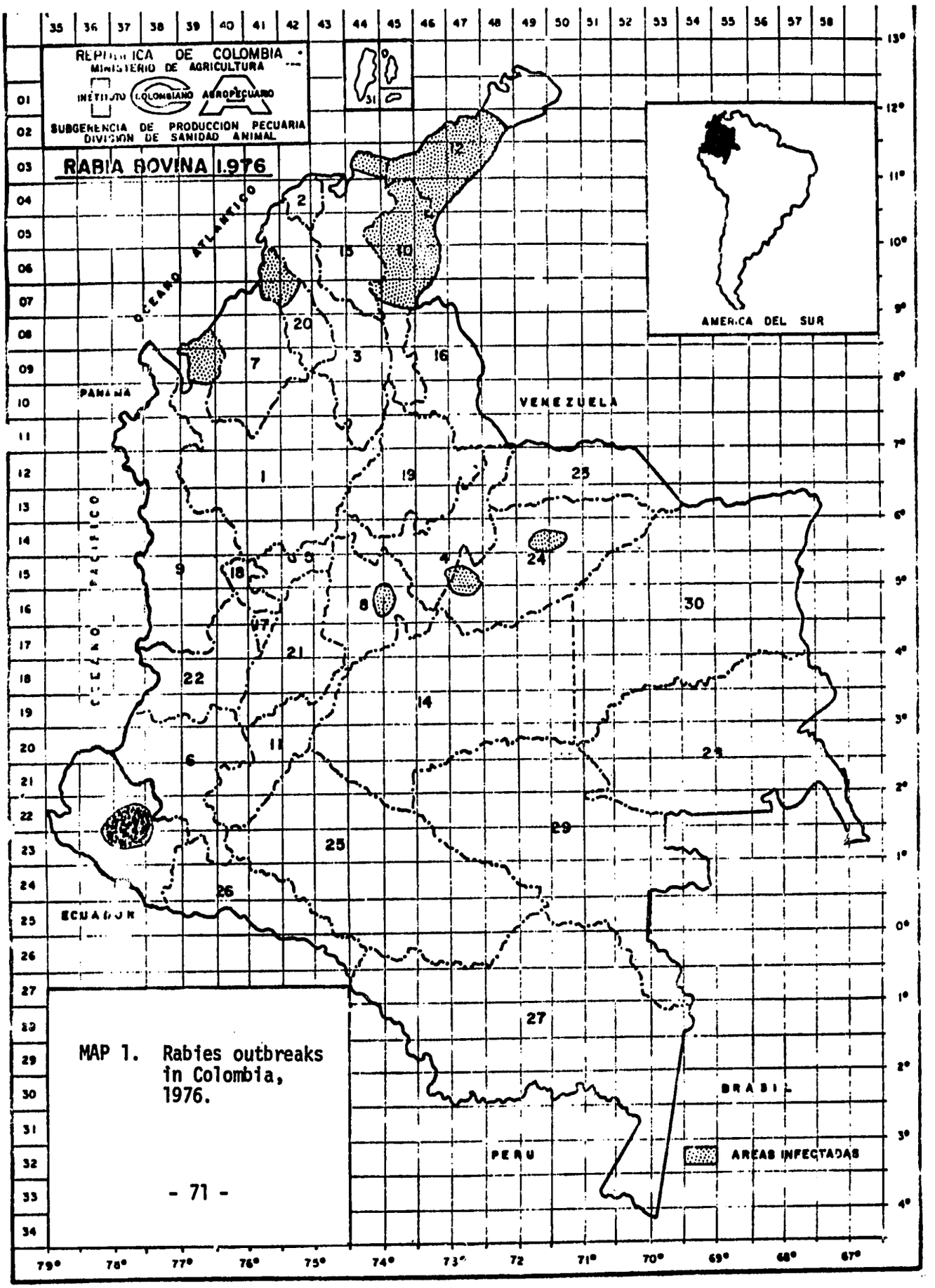
Honduras

Rabies is endemic in an 80-km^2 area in the Department of Atlantida. In 1976, rabies killed 236/1,174 cattle and 12/23 horses in this zone (Table 6).

The Honduran Ministry of Agriculture plans to work with Dr. Ramon Boyd, Chief of Rabies Control/Panama, and develop a control program in this region. Dr. Boyd will spend 2 months in Honduras next year attending a training seminar.

Mexico

The Ministry of Agriculture began a paralytic rabies control program in 1972. The program is staffed by 2 veterinarians in Mexico City and 15 veterinarians in the field.



MAP 1. Rabies outbreaks in Colombia, 1976.

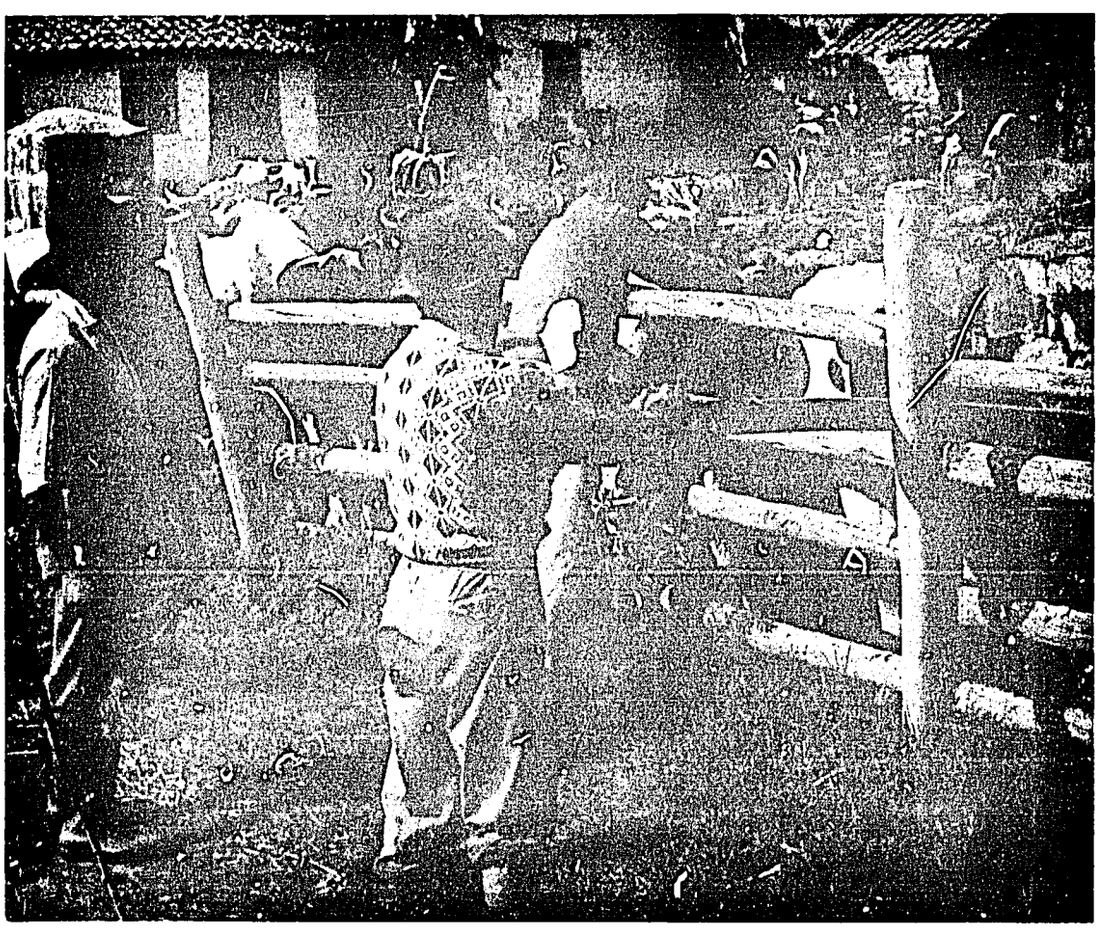


Fig. 1. Treating dairy cattle with Diphenadione in the Tambillo Valley, Ecuador.

Table 6. Paralytic rabies cases in the Municipalities of Esparta and Tela, Department of Atlantida, Honduras, 1976

Village	Cattle Population		Horse Population		Total Animal	Deaths	No. of Ranches
	Total	Deaths	Total	Deaths			
Arizona	347	53	4	4	351	57	7
Santa Maria	426	75	11	5	437	80	9
Sizama	26	3	0	0	26	3	2
Km. 17	187	17	6	2	193	19	8
Coloradito	71	4	0	0	71	4	3
San José	23	3	0	0	23	3	2
El Suspiro	N.I.	1	0	0	N.I.	1	1
Jilamo	N.I.	11	0	0	N.I.	11	1
Ceibita Way	18	4	0	0	18	4	1
Rio Plátano	N.I.	15	2	1	2	16	3
El Cedro	33	3	0	0	33	3	1
El Dorado	N.I.	46	N.I.	6	N.I.	52	8
Paris de Lean	48	1	0	0	48	1	1
Total	1,174	236	23	12	1,202	254	47

N.I. = No information.

Utilized in the campaign are two products of research developed at Mexico's National Agricultural Research Institute: (1) the rabies vaccine Cepa V-319 developed by Institute and FAO personnel, and (2) vampire bat control methods developed by Institute and AID personnel.

Prior to initiation of this campaign, Mexican officials estimated 2% of their cattle died annually from vampire bat-transmitted rabies. They estimated 100,000 cattle died in 1968 (Table 7). During the 4-year national campaign a total of 5,540,110 cattle have been vaccinated with Cepa V-319 and actual rabies losses reduced to 0.17% (Table 7).

Table 7. Results from the national campaign for the control of rabies

Year	Cattle Vaccinated	Cattle Deaths From Rabies
1968		100,000 (INIP/FAO)
1972	461,781	4,244
1973	893,252	1,689
1974	1,919,379	1,298
1975	2,143,428	1,133
1976*	122,270	309
Total	5,540,110	8,673

*Activities from January to March.

At the same time that cattle have been vaccinated, vampire bat populations have been reduced using the topical technique. Bats are captured with mist nets that are set around corralled cattle or at cave entrances.

Listed in Table 8 are the numbers of cave populations treated since 1972 and the total number of vampires treated. The Mexicans have no way to estimate their vampire population in these areas where they have worked, but feel the control program is very effective since biting has been reduced 90-95% in the treated zones.

Table 8. Vampire bat control in Mexico, 1972-1976

Year	No. Caves Located	No. Vampires Captured and Treated
1972	71	1,386
1973	319	12,046
1974	162	5,609
1975	238	8,520
1976*	54	2,013
Total	844	29,574

*Activities from January to March.

Nicaragua

Three-year results have been tabulated from the national campaign for vampire bat control. Results are as follows:

Cattle examined - 240,461
Fresh bites before control - 114,629
Cattle treated - 134,692
Vampires treated - 2,338
Reduction in fresh bites after control - 90.7%

The main cattle-producing area of Nicaragua is the western half of the country. The vampire teams have completed control work in a large portion of this area. From a 2-year follow-up study it appears biting remains low for at least this time period.

In 1977, the Ministry plans to broaden this program to other livestock problems. In addition to controlling vampires, they will also collect data on rabies in dogs, tick infestation in cattle, screw worm infestation, and problems with horn flies. Basically, these data will be collected prior to national campaigns to control these plagues.

Panama

The Ministry of Agriculture has elevated their vampire bat control program to a national level. Dr. Ramon Boyd is the chief of rabies control and they plan for 1977 to have nine veterinarians stationed throughout the country working exclusively on rabies control.

Laboratory-confirmed bovine rabies have occurred since 1957 in Panama but fail to follow the typical outbreak patterns (Table 9). Normally, many animals will die in an outbreak area, but in Panama only isolated cases appear sporatically each year. Because of this, several rabies specialists believe vampire bats are not the vectors. This is further supported by the fact that there has never been a vampire bat found positive for rabies in Panama. Dr. Boyd plans to sample vampire populations in regions where confirmed rabies deaths occur to determine if they are the vectors.

Panama began their campaign in May 1975 in the Provinces of Colon and Panama since most rabies cases have been reported from these provinces. One-year results are as follows:

Animals Examined	Fresh Bites	Cattle Treated	Vampires Treated	Reduction in Biting (%)
20,123	3,314	2,000	1,400	85

Paraguay

In 1975, Paraguayans estimated 17,043 cattle died from paralytic rabies. This represents a loss of $1,704,300. Rabies cases occur throughout most of the country (see Map 2).

Recently, the Ministry of Agriculture submitted their proposal for an Interamerican Development Bank loan. Included in the proposal is a request for funding to cover the three most costly diseases to the livestock industry: foot-and-mouth disease, brucellosis, and rabies.

The rabies program submitted includes vaccinating cattle and controlling vampire populations. Tentatively six veterinarians would be stationed throughout the area affected by rabies (see Map 3). It is expected that the Ministry of Agriculture will ask for assistance from AID when the control program is initiated.

Venezuela

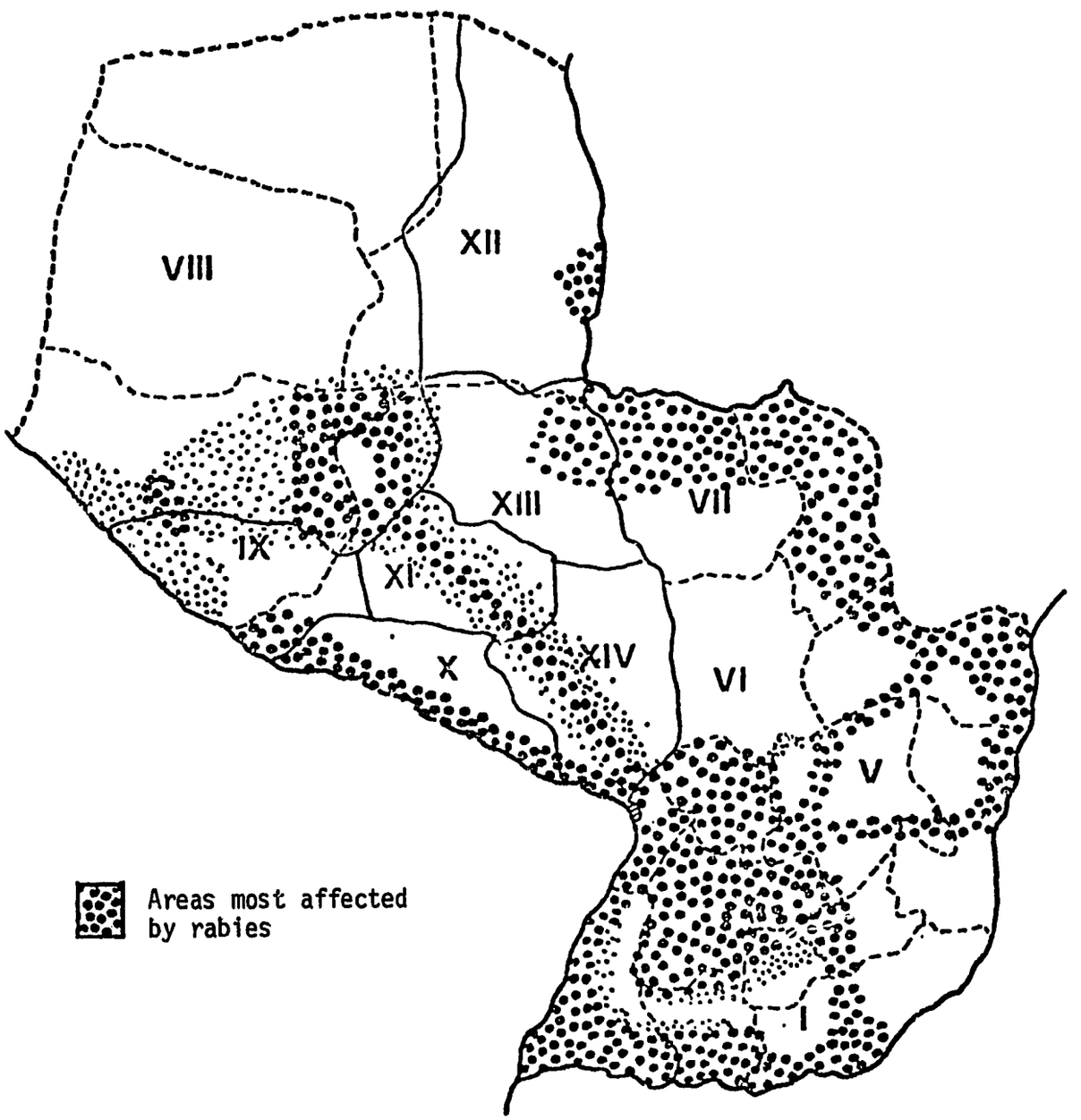
Dr. Rexford Lord of the Pan American Health Organization is stationed in Maracay. Though working on rabies research, he also assists the Ministry of Agriculture in rabies control. When there is an outbreak, he studies the direction of the movement and after this has been defined, he moves ahead of the advancement and reduces the vampire population by applying the topical control method.

Table 9. Laboratory-confirmed bovine paralytic rabies cases in Panama, 1957-1976

Year	Department (State)											Total
	Bocas del Toro	Chiriqui	Veraguas	Herrera	Los Santos	Cocle	Panama	Colon	Canal	San Blas	Darien	
1957	-	1	-	-	-	-	-	-	-	-	1	2
1958	-	-	-	-	-	1	-	-	-	1	-	2
1959	-	-	-	-	-	-	-	-	2	-	-	2
1960	-	-	-	-	-	-	-	3	-	1	-	4
1961	-	-	-	-	-	-	1	-	-	-	-	1
1962	-	-	-	-	-	-	-	-	-	-	1	1
1963	-	3	-	-	-	-	-	-	-	-	1	4
1964	-	-	-	-	-	1	-	1	-	-	1	3
1965	-	-	-	-	-	-	-	-	-	-	1	1
1966	2	2	-	-	-	-	2	-	-	-	-	6
1967	-	-	2	-	1	1	4	1	-	-	-	9
1968	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-
1970	-	4	2	-	-	-	4	-	-	3	-	13
1971	-	18	-	-	-	-	-	-	-	-	-	18
1972	-	10	-	-	-	-	-	-	-	-	-	10
1973	-	7	-	-	-	-	3	2	-	-	-	12
1974	-	-	-	1	1	1	-	10	-	-	-	13
1975	-	-	-	-	1	1	7	12	-	-	-	21
1976	-	-	2	-	-	3	12	1	-	-	2	20
Total	2	45	6	1	3	8	33	30	2	5	7	142

MAP 2

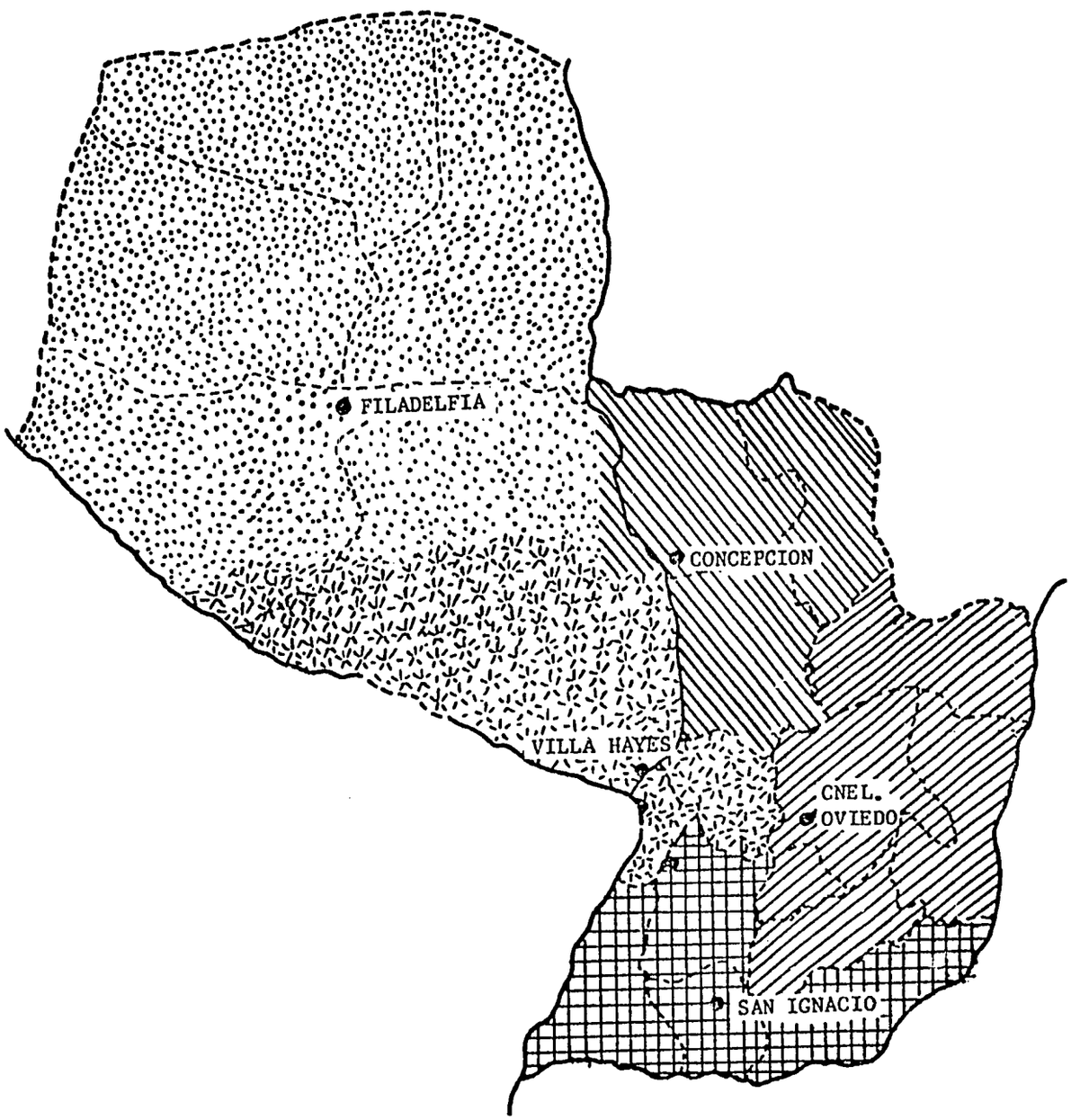
Distribution of Rabies in Paraguay



MAP 3

Location of Rabies Control Teams in Paraguay

and Areas They Will Work



FIRST INTERNATIONAL SYMPOSIUM ON THE CONTROL OF VAMPIRE BATS

On June 29-30, the Ministry of Agriculture/Nicaragua sponsored an international conference on the control of vampire bats (Fig. 2). Forty-six scientists from 11 countries participated in the symposium (Appendix A). The main objective was to discuss existing control campaigns and to determine what additional research is needed to guarantee the efficacy and safety of the control methods. A copy of the program is listed under Appendix B.

In the inauguration, the United States Ambassador to Nicaragua, the Honorable James Therberge, presented to the people of Nicaragua a special citation commending them on their vampire bat control program (Fig. 3). A translation of the award reads: "The Agency of International Development wishes to commend the people of the Republic of Nicaragua. They are the leaders in controlling paralytic rabies by reducing vampire bat populations. Nicaraguans have applied technology which will benefit the entire Latin American livestock industry." The award was signed by Administrator Parker, Head of AID.

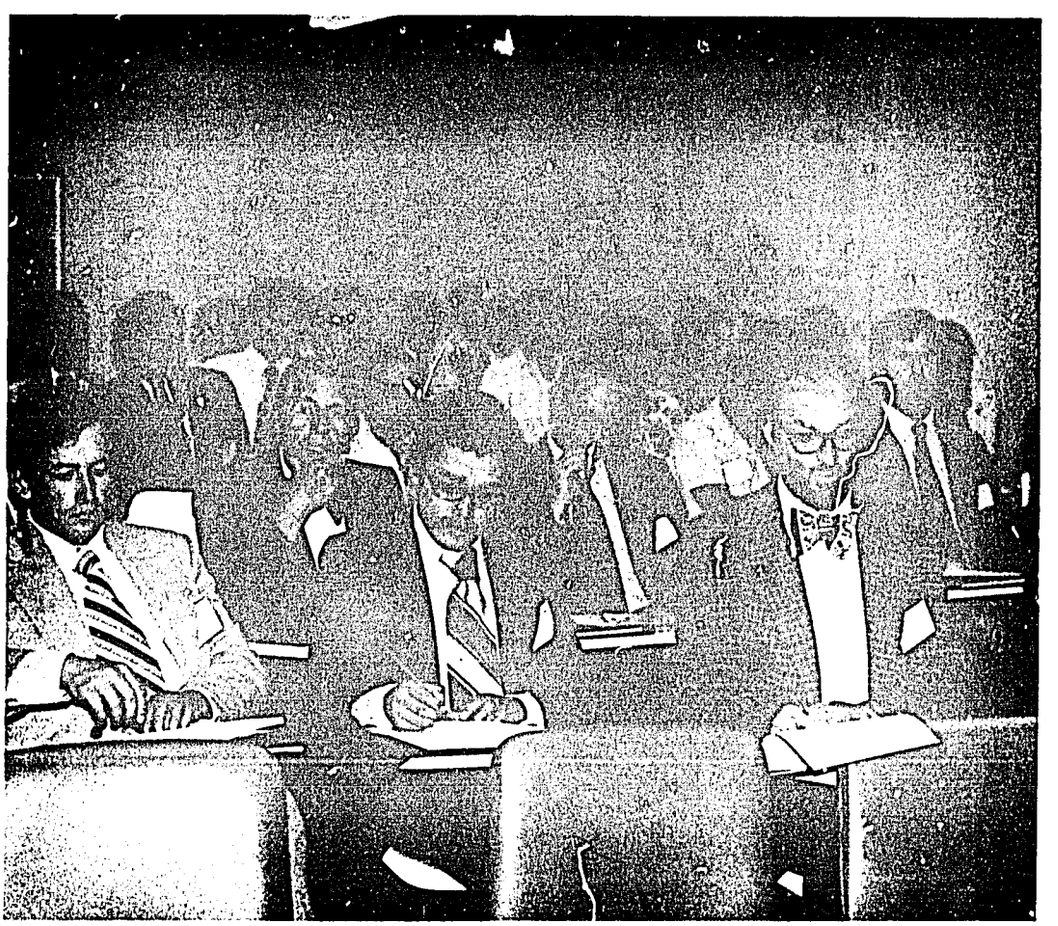
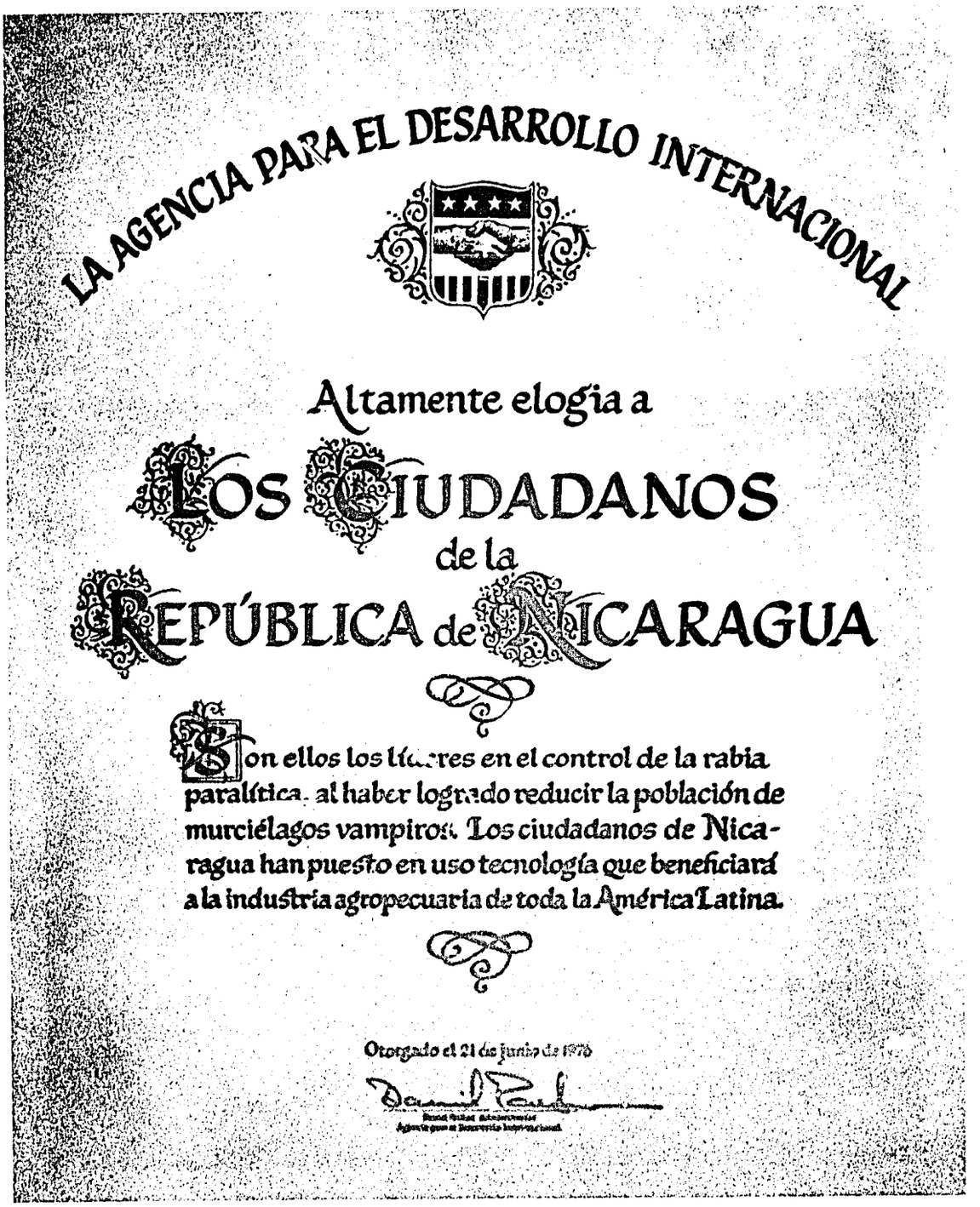


Fig. 2. Participants at the Vampire Bat Control Confereence held in Managua, Nicaragua.



LA AGENCIA PARA EL DESARROLLO INTERNACIONAL

Altamente elogia a

LOS CIUDADANOS

de la

REPÚBLICA de NICARAGUA

Son ellos los líderes en el control de la rabia paralítica, al haber logrado reducir la población de murciélagos vampiros. Los ciudadanos de Nicaragua han puesto en uso tecnología que beneficiará a la industria agropecuaria de toda la América Latina.

Otorgado el 21 de junio de 1978

Fig. 3. A commendation from AID to the people of Nicaragua in recognition of their outstanding vampire bat control program.

APPENDIX A. Participants at the Symposium on Vampire Bat Control, Managua, Nicaragua

Belize

Timothy J. McCarthy
Biologist
Department of Agriculture, U.S. Peace Corps

Colombia

German Bello G.
Director Programa de Epidemiologia
Instituto Colombiano Agropecuario

Republica Dominicana

Marcos Peña Franjul
Parque Zoologico Nacional
Universidad Nacional Pedro Henriquez Ureña
Santo Domingo

El Salvador

Jose A. Ferrer R.
Jefe Sanidad Animal Oirsa
San Salvador

Oscar Arevalo
Campaña Nacional Contra Rabia Paralitica
Medico de Campo
Ministerio de Agricultura y Ganaderia

Roberto Hernandez
Campaña Nacional Contra Rabia Paralitica
Medico de Campo
Ministerio de Agricultura y Ganaderia

Roger Feldman
Director, Central America Research Station
(CDC) USPHS

Guatèmala

Edgard Ortiz Aldana
Jefe Administrativo I
Ministerio de Agricultura

APPENDIX A (cont'd)

Honduras

Oscar Umaña
Medico Veterinario Oirsa

Mexico

Victor M. Hernandez
Tecnico Agropecuario

Raul Flores Crespo
Jefe Programa Control de Vampiros
INIPSAG

Luis Manriquez M.
Jefe de la Campaña Nacional
Contra el Derriengue
Secretaria de Agricultura y Ganaderia

Nicaragua

John H. Wyss
Contraparte Convenio Bilateral Antiaftoso
Departamento de Agricultura de los Estados Unidos

Daly Gutierrez N.
Zootecnista Inst. Nut. Animal
Universidad Centroamericana

Juan B. Rodriguez
Veterinario Oficial
Accion Civica G.N.

Jose A. Lainez T.
Jefe Division Ganadera
Banco Nacional de Nicaragua

Adan Barillas C.
Jefe Seccion de Ganado Vacuno
Banco Nacional de Nicaragua

Ricardo Valle B.
Jefe Seccion de Ganado Menor
Banco Nacional de Nicaragua

Arturo Tewes
Asesor Veterinario
Latinoconsult
Banco Nacional de Nicaragua

APPENDIX A (cont'd)

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APPENDIX B. Program of the Symposium on Vampire Bat Control, Managua, Nicaragua

29 June 1976

8:00 a.m.	Registration
9:00 a.m.	Words from Dr. Charles M. Loveless, Director of the Denver Wildlife Research Center, Denver, Colorado.
9:15 a.m.	Presentation of an award by the Honorable James Theberge, Ambassador from the United States of America, to the Honorable Luis Osorio G., Vice-Minister of Agriculture and Livestock.
9:30 a.m.	Inauguration by the Honorable Luis Osorio G., Vice-Minister of Agriculture and Livestock.
9:45 a.m.	Recess
	- FIRST WORKING SESSION -
10:00 a.m.	Efficacy and safety of the topical method for the control of vampire bats with Diphenadione. G. Clay Mitchell*, Richard J. Burns, and Roger W. Bullard, USA.
	*Read by Mitchell
11:00 a.m.	Efficacy and safety of the systemic method of vampire bat control. Roger W. Bullard* and R. Daniel Thompson, USA.
	*Read by Bullard
12:00 noon	Discussion
	- SECOND WORKING SESSION -
2:30 p.m.	Effects of vampire bat parasitism on bovine milk production. R. Daniel Thompson*, Donald J. Elias, and G. Clay Mitchell, USA.
	*Read by Thompson
3:15 p.m.	Effects of the anticoagulant Diphenadione on suckling calves. Donald J. Elias*, R. Daniel Thompson, and Peter J. Savarie, USA.
	*Read by Elias

APPENDIX B (cont'd)

4:00 p.m.	Recess
4:15 p.m.	The vampire bat control program in Mexico. Dr. Luis Manriquez M., Mexico.
5:00 p.m.	An optimum method for controlling vampire bats in Latin America. Dr. Dennis C. Turner, Switzerland.
6:00 p.m.	Discussion

- THIRD WORKING SESSION -

30 June 1976

8:30 a.m.	Chemical control of vampire bats in Panama. Dr. Ramon Boyd, Panama.
9:00 a.m.	Information on the advances in the campaign to control bovine rabies in Colombia. Dr. German Bello, Colombia.
9:30 a.m.	The control of vampire bats in Belize: With reference to education, investigation, and control. Dr. Timothy McCarthy, Belize.
10:00 a.m.	Recess
10:30 a.m.	Vampirinip II: Topical method of control. Dr. Raul Flores Crespo, Mexico.
11:00 a.m.	Vampirinip III: Systemic method of control. Dr. Raul Flores Crespo, Mexico.
11:30 a.m.	A film on vampire bat research in Mexico. Dr. Raul Flores Crespo, Mexico.
12:00 noon	Discussion

- FOURTH WORKING SESSION -

3:00 p.m.	The vampire bat control program in Nicaragua. Dr. Rodrigo Gonzalez, Nicaragua.
4:00 p.m.	Round Table Discussion

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