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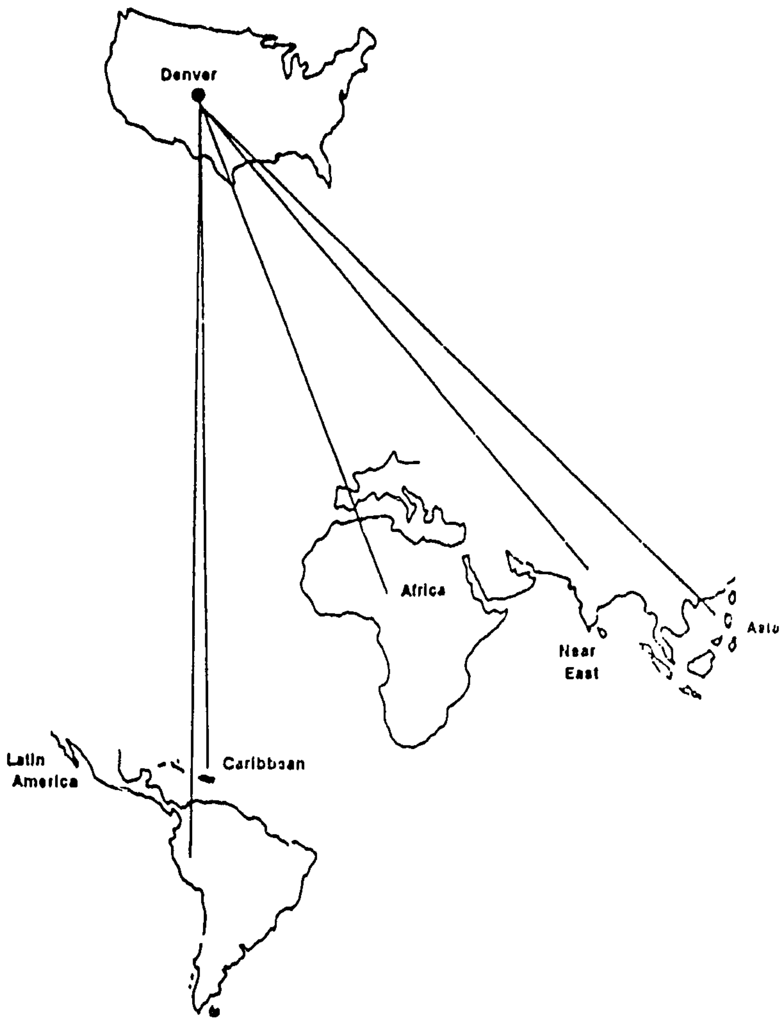
DENVER WILDLIFE RESEARCH CENTER

VERTEBRATE PEST MANAGEMENT IN AGRICULTURE

INTERNATIONAL OUTREACH PROGRAM—FY 1989

PROBLEM SOLVING RESEARCH   TECHNOLOGY TRANSFER   EXTENSION
TRAINING   CONSULTANCIES   DOCUMENTATION



U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
ANIMAL DAMAGE CONTROL

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

United States Department of Agriculture

Animal and Plant Health Inspection Service

Science and Technology

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OUTREACH ACTIVITIES

International Programs Research Section

December 1989

This document is a compilation of trip reports resulting from international requests for Denver Wildlife Research Center (DWRC) technical assistance in vertebrate pest management. During Fiscal Year 1989, DWRC staff traveled to the following countries in Asia, the Caribbean, Latin America, Africa, and Europe to assess vertebrate pest problems; to conduct, review, evaluate, and coordinate present and future activities; to participate in training workshops; and to present technical seminars.

Antigua/Barbuda	Dominica	Pakistan
Bangladesh	Grenada	Senegal
Barbados	Italy	St. Kitts/Nevis
Bhutan	Mauritania	St. Lucia
Chad	Morocco	St. Vincent/Grenadines

These consultancies were at the request of the U.S. Agency for International Development (USAID), USAID Missions, USAID/Washington, the Food and Agriculture Organization (FAO) of the United Nations, and foreign governments. TDY activities from DWRC have become increasingly important, and DWRC will continue to respond to these requests. A summary of the activities undertaken during these consultancies precedes the trip reports.

Richard Bruggers

Richard L. Bruggers
Chief, International Programs Research Section

PROJECT TITLE: International Vertebrate Pest Management Program--DWRC

PROJECT LEADER: Richard L. Bruggers, (303) 236-7850

INTRODUCTION:

In 1967, a cooperative program was established between the Administrator, U.S. Agency for International Development (AID), and the Secretary of the Interior delegating the U.S. Fish and Wildlife Service to conduct studies to reduce food losses caused by rats, bats, and noxious birds on a worldwide basis. This cooperative agreement was continued with the U.S. Department of Agriculture (USDA)/Animal and Plant Health Inspection Service (APHIS) with the transfer of Animal Damage Control (ADC) from USDI to USDA on December 19, 1985. In October 1988, the DWRC was further transferred from APHIS/ADC to APHIS/Science and Technology. Funds are provided to DWRC by USAID Missions, regional bureaus, and the USAID Bureau of Science and Technology to maintain a core group of international vertebrate pest specialists in the International Programs Research Section (IPRS) at the DWRC to implement the cooperative agreement. The program goal is to evaluate vertebrate pest situations in Asia, Latin America, and Africa and, when circumstances warrant, develop and implement environmentally acceptable methods to reduce vertebrate pest damage. International vertebrate pest management requires field visits, liaison, and ongoing interchange with pest control research and implementation organizations--both domestic and foreign. Goals are accomplished by in-country programs, TDY activities, supervisory and administrative functions from the DWRC, and problem-oriented research and training using expertise available at the DWRC.

OBJECTIVES:

1. Provide supervisory, administrative, and temporary duty (TDY) support for foreign field stations.

2. Conduct cooperative problem-oriented research at DWRC based upon field program priorities.

3. Develop and implement proposals for vertebrate pest management (VPM) programs worldwide.

4. Provide scientific support, on request, to AID/Washington, USAID Missions, and foreign governments by:

    a. Providing TDY technical assistance to developing countries.

    b. Arranging and providing training for foreign VPM technicians, administrators, and graduate students at DWRC.

    c. Coordinating VPM participation in international workshops, symposia, and conferences.

    d. Responding to inquiries and foreign assistance requests to DWRC through correspondence, reports, publications, and cooperative research.

5. Work closely with international organizations, such as the Food and Agriculture Organization (FAO) of the United Nations, World Bank, Desert Locust Control Organization for East Africa (DLCO-EA), and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) on research problems of mutual interest.

6. Perform supervisory and program development functions at DWRC.

ACCOMPLISHMENTS DURING FY-89:

TDY Trips

During 1989, DWRC staff traveled to Asia, the Caribbean, Africa, and Europe at the request of USAID, USAID Missions, USAID/Washington, FAO, and foreign governments to assess vertebrate pest problems; to review, evaluate, and coordinate present and future research programs; to evaluate the impact on the environment and nontarget wildlife of locust control sprays; and to present seminars. TDY activities from DWRC are an important part of the project, and DWRC will continue to respond to such requests, as many types of short-term evaluations and cooperative studies with host-country scientists may be carried out expeditiously in this manner. Travel during FY-89 involved 341 person-days.

Mr. Keith LaVoie, Wildlife Biologist, IPRS, worked in Bhutan from September 26 to October 26, 1988, on a consultancy for FAO, to evaluate the impact of rodents in grain storage facilities. The degree of infestation ranged from moderate to intense and seemed to be related to the length of time a crop was stored, the physical condition of the storage structure, and the associated sanitation conditions. It was estimated that about 4% of the food stores were consumed by rodents and an additional 10-20% were contaminated. It appeared that the rodent problem could be alleviated in some of these situations through proper structural modifications and maintenance. Training of Ministry of Agriculture (MOA) personnel in sanitation and control methods would also reduce losses and health hazards from rodents.

Mr. Edward Knittle, Wildlife Biologist, Chemical Development/Registration Section, and Dr. Richard Dolbeer, Wildlife Biologist, Bird Control Research Section, completed a 6-week consultancy (October 10 to November 24) requested through the IPRS by USAID/Senegal as part of a team to monitor the general conditions under which pesticides were being stored, transported, handled, and applied during emergency locust control operations and to identify the impact of spraying locusts on nontarget wildlife in west Africa. These were DWRC's first consultancies to assess the impact of large-scale locust control operations on nontarget wildlife.

Mr. Lynwood Fiedler, Wildlife Biologist, IPRS, visited the Pakistan Vertebrate Pest Control Project (VPCP) between October 14 and November 8 to assist Project staff in implementing project activities for the remainder of the current project (until June 1990), testing a method to evaluate rodent damage to groundnut, and evaluating training materials and subject matter for the master's training agenda.

Mr. Keith LaVoie traveled to Senegal between January 29 and February 21, 1989, to work with the MOA to gather data on chronic rodent infestation in crops in the Senegal River Valley. This activity involved identifying pest rodent species and quantifying damage. This was one of several consultancies planned for 1989 to Sahelian countries to better define the chronic rodent pest situation.

Dr. George Matschke, Wildlife Biologist, Mammal Control Research Section, traveled to Pakistan between February 3 and March 6 to assist the USAID/DWRC/VPCP in wild boar biology and control. Dr. Matschke assisted VPCP scientists and DWRC Project Leader (Mr. Joe Brooks) in designing a 4-year research proposal. In addition, he assisted and demonstrated techniques of live-trapping, chemical immobilization, and radiotracking, and began evaluating potential chemical toxicants as control methods.

Mr. Lynwood Fiedler traveled to the eastern Caribbean from February 8 to March 2 in the last of four consultancies sponsored by FAO to assist several islands to implement rodent pest management to reduce food losses. The islands receiving this technical assistance include Barbados, St. Kitts, Antigua, Dominica, St. Lucia, St. Vincent, and Grenada.

Dr. Richard Bruggers, Chief, IPRS, traveled to Bangladesh and Pakistan from March 29 to April 15 to assist the Project Leader in Dhaka, Bangladesh (Dr. Michael Jaeger) in preparing for an upcoming external review of the Vertebrate Pest Project and in planning the direction of activities for the remainder of the project. Dr. Bruggers also assisted the DWRC Project Leader in Pakistan in planning project activities through June 1990 and investigating the feasibility of various options for DWRC assistance to the Government of Pakistan (GOP) beyond June 1990.

Dr. James Keith, Wildlife Biologist, IPRS, consulted in Morocco from March 31 to April 9 at the request of USAID/Rabat to initiate a project to evaluate the direct (toxic) effects of locust control sprays of malathion and fenitrothion on the environment and nontarget wildlife. This project will involve cooperative studies with the Government of Morocco, the Peace Corps, and USAID. A proposal for FY-90 was developed which consists of three phases--training of Moroccan scientists, gathering of baseline data, and finally, the experimental application and evaluation of insecticides to study areas.

The necessary documents were finalized by USAID to establish a new USAID/DWRC field station in Chad, Africa. This field station will begin in FY-90 and will be involved in setting up a rodent population monitoring system, assessing acute and chronic rodent damage, evaluating and field testing bait delivery systems and providing the necessary training to Chadian scientists to eventually implement their own rodent management program. Mr. Lynwood Fiedler visited Chad, from April 23 to May 12 to determine the logistic considerations and requirements for establishing this rodent field station. Discussions were held with personnel of AID/N'Djamena and Chad MOA regarding a number of points related to personal (housing, vehicle recreation, consumables, etc.) and work-related (office, vehicle, contract logistical support services, etc.) needs.

Dr. James Keith also was in Senegal from June 27 to September 3 and again from September 11 to October 13 to conduct studies of the impact on birds of the use of insecticides to control African migratory locusts and grasshoppers. These studies were conducted cooperatively by FAO, France, the Netherlands, Senegal, the United Kingdom, and the United States. The study team included aquatic biologists, ecologists, terrestrial entomologists, ichthyologists, ornithologists, a pesticide application specialist, an expert in soil micro-organisms, and toxicologists. The extent of ecological and biological processes covered by the study team was extensive, and results should provide a good basic assessment of the kinds of environmental effects that result from applications of fenitrothion and chlorpyrifos.

Mr. Lynwood Fiedler was in Bangladesh from September 24 to October 18, 1989, to assist the Government of Bangladesh and the USAID/DWRC-supported Vertebrate Pest Section and DWRC Project Leader in implementing a large-scale pilot demonstration of rodent control in rice. This rodent control demonstration was conducted in two 48-km^2 sites and tested the field efficacy and farmer acceptance of two control techniques and a rodent management strategy.

Supportive Research Activities

In 1988, a DWRC consultancy supported by FAO enabled an evaluation of the environmental effects of fenthion used for quelea control in Kenya. The team organized to conduct this work consisted of two IPRS biologists, Analytical Chemistry Section chemists, the FAO quelea project leader in Nairobi, and Mr. John Ngondi, a senior pest control specialist in the Kenya MOA. The fieldwork was conducted in Kenya during August 1988. Fenthion residue analyses in samples were begun in 1989 and are continuing, and Mr. Ngondi worked at DWRC from March 13 to April 3, 1989, to begin preparation of a manuscript reporting results of the research.

Studies have continued toward developing a low-cost, nonedible carrier for rodenticides that can be used in both rat burrows and in storage structures. The belief is that rodents will ingest the toxicant when attempting to remove the carrier while grooming. This may eliminate some of the current problems with ingested baits such as bait novelty, preferences, and shyness.

The DWRC Analytical Chemistry Section completed an assay of over 100 samples of the rodenticide zinc phosphide, which was purchased from local markets in Bangladesh. Twenty of 21 samples were <80% pure, with 15 of 21 samples having less than 40% a.i. These results may partially explain why farmers no longer purchase the material for rodent control in Bangladesh.

Participation in Meetings, Conferences, Seminars

Dr. James Keith attended the 1st Annual Conference for the Society for Ecological Restoration and Management in Oakland, California, between January 16 and 20, 1989. The purpose of the Society is to encourage the development of ecological restoration and management as a scientific discipline and a strategy for environmental conservation.

Messrs. Lynwood Fiedler and Keith LaVoie attended the 9th Great Plains Wildlife Damage Control Workshop in Fort Collins on April 19.

Dr. James Keith participated in the 1989 Desert Locust Grasshopper Workshop in Dakar, Senegal, between February 6 and 9. The workshop discussed the current locust situation in the Sudan/Sahelian countries, the country action plans for 1989, technical aspects of locust control, and environmental issues. Participants included representatives from the USAID Missions, Office of Foreign Disaster Assistance, FAO, and international locust control experts. Following this meeting, Dr. Keith was at FAO headquarters, Rome, between February 13 and 17 to represent USAID at a Working Group Session to design an FAO/Dutch/British/American environmental assessment project. DWRC/IPRS involvement in the development of this multination research effort was from the standpoint of trying to minimize the impact of chemical control operations (e.g., locusts and perhaps birds and rodents) on the environment and nontarget wildlife.

Dr. Keith was invited to speak at Ohio State University on May 5 on "The history of DDT, its uses, and environmental effects." His talk was part of a seminar series on "Technology and the Environment" that was organized by Dr. Tony Peterle. Invited speakers from throughout the United States and Canada participated in these seminars to help inform students and the general public about the environmental limits that exist to the use of technology.

Training

IPRS continued collaboration with the Department of Wildlife and Fisheries of Colorado State University (CSU), Fort Collins, in international vertebrate pest management training. DWRC biologists continued to teach classes in the biennial VPM course during the fall semester. Assistance was provided to Mr. Md. Sayed Ahmed, an International Rice Research Institute-sponsored Ph.D. candidate, in developing a research proposal to develop a toxicant delivery system utilizing rodent grooming behavior applicable to *Bandicota bengalensis*, for use by Bangladesh farmers. Agreement was reached to permit Messrs. Yousuf Mian and Ejaz Ahmad, DWRC project counterparts at the Bangladesh Agricultural Research Institute and the National Agricultural Research Centre in Pakistan, respectively, to formally apply for admittance into Ph.D. programs.

DWRC and CSU completed on August 25 their 2nd International Short Course in Vertebrate Pest Problems and Solutions in Developing Countries. Twelve individuals from the countries of Bangladesh, Guinea-Bissau, Indonesia, Japan, Malawi, Mexico, Philippines, and Uganda attended this 2-week course, which was organized by IPRS. About 50 individuals from the United States (including 30 DWRC staff members), Argentina, Australia, England, Hungary, and Uruguay presented information. Topics included basic field and laboratory research techniques; pre- and postharvest pest problem identification; field demonstrations of control techniques and crop protection methods; specialized marking, monitoring and surveillance techniques; library information attainment, exchange, and retrieval;

computer applications and statistical considerations; and pest management strategies.

Mr. Rajat Pandit, Scientific Officer from the Vertebrate Pest Section, Bangladesh Agricultural Research Institute, Joydebpur, Bangladesh, successfully completed a 6-week predator pest research consultation with DWRC. Mr. Pandit spent the period of July 31 to August 12 at the DWRC Predator Research Field Station in Logan, Utah, where he worked with Project Leader Dr. Fred Knowlton. Between August 28 and September 8, Mr. Pandit worked at the DWRC headquarters in Denver where he was involved in a variety of predator-related activities, including making sonograms of jackal calls, collecting over 200 predator publications, setting traps and snares at a Colorado ranch where sheep were being killed, discussing research proposals, and acquiring experience using a bibliographic reference computer program, Procite.

A week of training in computer use was provided to the Bangladesh Project Leader at DWRC in conjunction with his home leave. Programs were developed for establishing data sets on the project computer soon to be purchased, and graphics were reproduced by computer for use in project reports, seminars, and publications.

Visitors

Dr. David Bathrick, Chief, Office of Agriculture, Bureau of Science and Technology (S&T)/AID, visited DWRC in October 1988 for orientation on the DWRC research capabilities and to discuss continued involvement of IPRS in the AID/S&T Bureau mandates.

During the week of March 6, 1989, IPRS hosted an external review team comprised of Mr. Allen Hankins, USAID, Asia Bureau, and Dr. William Jackson, Professor Emeritus from Bowling Green State University, Bowling Green, Ohio. The purpose of this review was to conduct a mid-term technical and performance evaluation of the implementation of the Vertebrate Pest Management Systems Participating Agency Service Agreement between USAID, S&T, USDA, and DWRC. The review team was extremely supportive of DWRC implementation of this AID-funded program.

On June 18 and 19, IPRS again hosted an external Review Team consisting of Drs. William Jackson and Paul Marko, Associate in Rural Development, Burlington, Vermont. The purpose of this review was to evaluate DWRC technical assistance and backstopping support to the USAID/DWRC vertebrate pest field station in Bangladesh. This second review team was also very positive about DWRC backstopping support to the Bangladesh project and to the entire project in general.

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Trip Reports

LaVoie, G. K. 1988. Trip Report--Bhutan. 14 pp. and 2 appendices.

Knittle, C. E. 1988. Trip Report--Senegal. 4 pp. and 1 appendix.

Fiedler, L. A. 1988. Project planning, groundnut rodent damage assessment, and wild boar research. Trip Report--Pakistan. 8 pp. and 2 appendices.

Dolbeer, R. A. 1988. Environmental assessment for U.S. Locust Control Program--Senegal. Trip Report--Senegal. 16 pp.

LaVoie, G. K. 1989. Trip Report--Senegal and Mauritania. 16 pp.

Matschke, G. H. 1989. Project planning and wild boar research. Trip Report--Pakistan. 14 pp.

Keith, J. O. 1989. Locust/Grasshopper Management Workshop and planning meeting studies of locust insecticide effects on the environment. Trip Report--Senegal and Italy. 5 pp. and 4 attachments.

Fiedler, L. A. 1989. Prevention of food losses through rodent control. Trip Report--Caribbean. 15 pp. and 2 appendices.

Bruggers, R. L. 1989. Trip Report--Bangladesh and Pakistan. 10 pp.

Keith, J. O. 1989. Trip Report--Morocco. 4 pp. and 2 attachments.

Fiedler, L. A. 1989. Planning for the establishment of the proposed rodent control project in Chad. Trip Report--Chad. 9 pp. and 4 appendices.

Keith, J. O. 1989. Environmental effects of insecticides used in locust control. Trip Report No. 1--Senegal. 4 pp. and 7 attachments.

Keith, J. O. 1989. Environmental effects of insecticides used in locust control. Trip Report No. 2--Senegal. 3 pp. and 4 attachments.

DRAFT

SUBJECT TO FAO REVIEW

TRIP REPORT*

PROBLEM ASSESSMENT OF RODENT INFESTATIONS IN STORES OF THE FOOD CORPORATION OF BHUTAN GCPS/BHU/006/NOR

September 26-October 26, 1988

G. Keith LaVoie
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Denver, Colorado USA

Unpublished Report

November 30, 1988

* This project was conducted with funds provided to the Denver Wildlife Research Center by the United Nations Food and Agriculture Organization under Project Number GCPS/BHU/006/NOR titled "Rodent Control."

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SUMMARY

Food Corporation of Bhutan (FCB) storage facilities in five geographic areas were assessed to determine the type and extent of rodent infestations. The primary pest species were found to be *Bandicota bengalensis*, *Rattus rattus*, *Rattus norvegicus*, and *Mus musculus*. The degree of infestations ranged from moderate to severe and was dependent on the duration of storage, type and condition of storage structures, and the degree of sanitation in and around the storage structures. Trapping data and observations from sampled structures suggest that a total of 70 Mt of FCB grain is consumed by rodents each year. An additional 700-1,400 Mt of grain in FCB structures are contaminated with rodent urine, feces, and hair. Health hazards from rodent contamination are extremely high. Recommendations include (1) training for select FCB personnel in rodent biology and behavior, rodent exclusion methods, sanitation, health hazards, and rodent control techniques; (2) rodent-proofing and sanitation of structures and a followup maintenance rodent control program in storage structures; and (3) the appointment of one trained, FCB individual to take charge of all vertebrate pest control in FCB stores.

INTRODUCTION

Terms of Reference

Rodent control consultant under the direction of the FCB Project Manager will:

1. determine the species of rodent infesting FCB stores;
2. estimate type and magnitude of damage caused and health hazards;
3. recommend physical and/or chemical control measures;
4. train counterpart in rodent identification and control;
5. draft project document for technical assistance to FCB in rodent control; and
6. prepare brief report on consultancy.

Dates of Consultancy

This mission began September 26 and terminated October 26, 1988. Briefing sessions were held at FAO offices in Thimphu on September 30 and again October 21 after the in-country surveys.

Background of Mission

There is virtually no historical precedent for rodent control in Bhutan. Consequently, FCB requested FAO assistance in problem definition, training, and recommendations for rodent control in FCB storage facilities. This mission addressed that request.

The FCB is a department of the Ministry of Agriculture of the Royal Government of Bhutan. The FCB consists of three primary divisions: Finance and Administration, Cash Crops, and Operations. Operations is made up of three subdivisions: World Food Program (WFP), Marketing, and Technical Services. Technical Services consists of sections handling Construction, Warehousing, Transport, and Quality Control. During this mission, I worked primarily with Technical Services personnel, my counterpart being Mr. Chimi Dorji, Senior Manager. The functions of FCB are transport, storage, and wholesale distribution of foods. These foods consist primarily of grain (rice, wheat, and maize), potatoes, fruit, salt fish, salt, and other miscellaneous items. The WFP stores included flour and pulses as well as wheat and rice. The FCB currently handles about 27,000 Mt of grain annually. This amount is expected to increase to over 60,000 Mt in 1989. This will amount to about 33% of the national cereal production of an estimated 182,000 Mt (FAO, 1986). The 1989 increase is expected to consist primarily of maize. Maize is currently exported, and it is anticipated that low cost and availability of local maize will decrease the importation of rice.

The FCB now has storage capacity for about 7,500 Mt (in about 50 structures with about 7,000 m^2 of usable area) of food from which about 3,000 Mt is used for grain storage; this figure includes WFP stores. Grains and other foods are stored for periods ranging from 1 week to many months.

SPECIES IDENTIFICATION

A total of eight FCB-owned or -leased storage structures in five geographic locations in Bhutan (see Fig. 1) were trapped to determine the primary rodent pest species. These data are summarized (Table 1). Three species of rats, the black rat (*R. rattus*), the brown rat (*R. norvegicus*), and the bandicoot rat (*B. bengalensis*) are the primary rat pest species. However, *B. bengalensis* were trapped at only one location, Phuntsholing. Only *R. rattus* were trapped above 1,000 m, while all *R. norvegicus* were trapped below that altitude. Longer trapping periods may alter the species composition and distribution, but these three commensal rats appear to be responsible for a major portion of the losses, contamination, and associated health hazards in most FCB storage facilities.

Mice (*Mus* spp.) were captured in all locations except Tongsa. Observations of droppings and sightings of mice and rat trap data indicate that this is the most numerous rodent pest in FCB storage stuctures. However, total trap success ratios do not support this contention. Although both rat traps and mouse traps were used, most of the mice were caught in rat traps. The mouse traps were generally ineffective, but the reason is not

Fig. 1. Map of Bhutan.

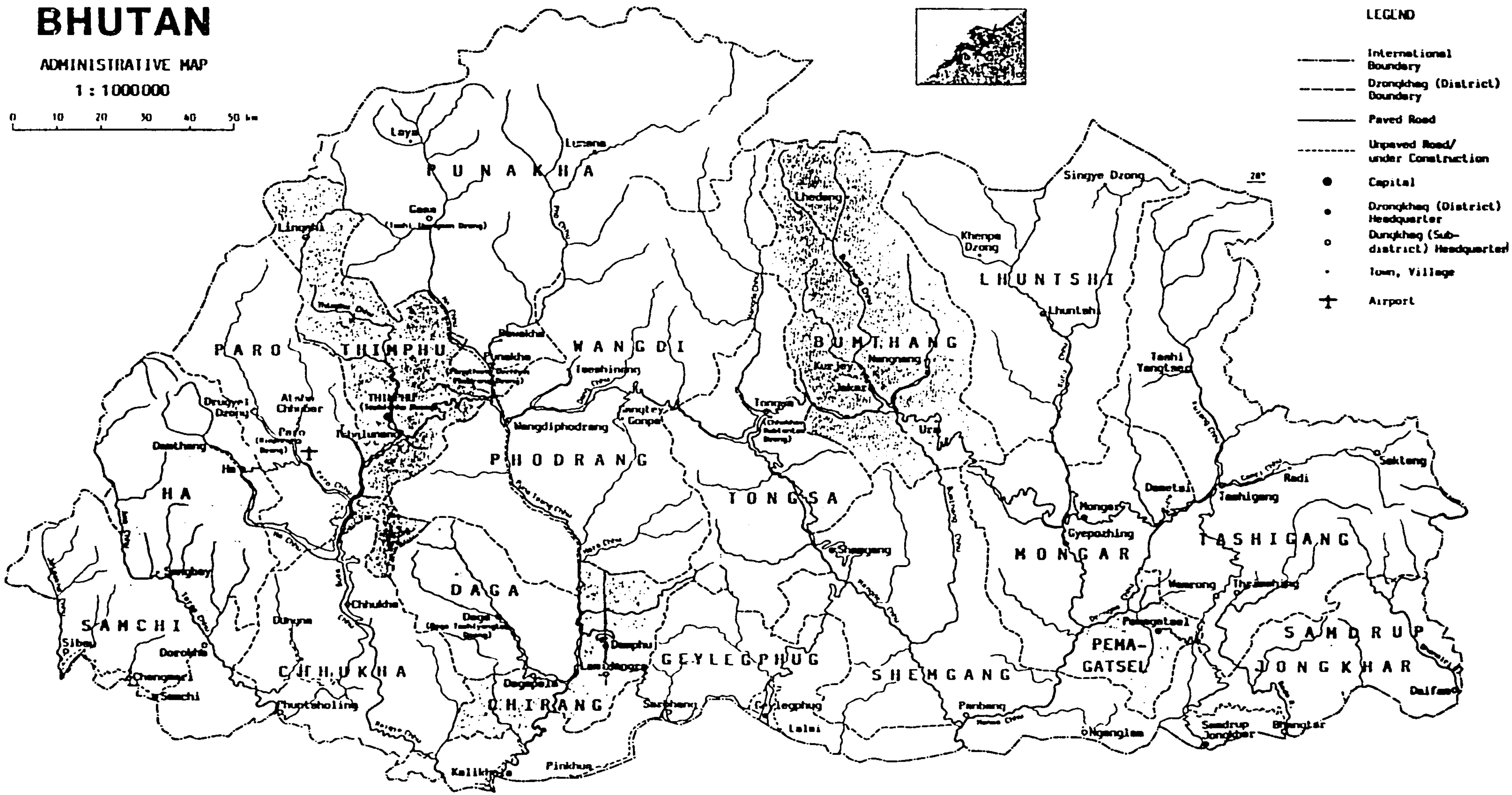

Table 1. Species identification and location of mammals trapped in FCB storage facilities in Bhutan.

Location	Approx. altitude (m)	FCB store No.	Species	No.[a] trapped	Trap nights[b] Rat traps	Mouse traps
Phuntsholing	150	H-3	*B. bengalensis*	8	20	20
			M. musculus	5		
			R. norvegicus	1		
			S. murinus	4		
		6	*B. bengalensis*	1	12	6
			S. murinus	2		
		H-6	*M. musculus*	0	3	48
Gaylegphung	150	WFP[c] (lease)	*R. norvegicus*	3	10	10
			M. musculus	2		
		21*	*R. rattus*	2	15	7
			R. spp.	1		
			M. musculus	7		
Damphu	1,200	28	*M. musculus*	9	15	9
Thimphu	2,300	17	*R. rattus*	7	16	16
			M. musculus	2		
			S. murinus	6		
Tongsa	2,600	H-18	*R. rattus*	1	10	10
Totals				61	101	126

[a] Rats, 24; mice, 25; shrews, 12.

[b] Total trap success = 26.8%; however, trap success from rat traps alone was approximately 40%.

[c] WFP = World Food Program

clear. Some variation in body characteristics was noted among trapped mice. It is probable that more than one species of Mus are present in some FCB storage structures. Specimens were collected from these buildings and will be examined to assure exact species identities.

The Asiatic house shrew (Suncus murinus) was also captured in Phuntsholing and Thimphu, indicating a wide, but not surprising distribution. This small mammal is not a rodent, but an insectivore. It may seasonally consume some grain, however; it also causes health hazards from contamination of food and liquids, i.e. leptospirosis (Benenson, 1980).

MAGNITUDE OF RODENT DAMAGE

A total of 20 storage facilities in five geographic locations were inspected. The magnitude of infestation in all structures was estimated based on the number of droppings, sightings, and tracks. Traps set in 8 of the storage structures tended to confirm estimated infestation levels shown in Table 2. A total of 9 of the 20 structures sampled was heavily infested with rats and mice or mice only. Again, mice are probably the most widely distributed and numerous species in FCB storage structures. In Phuntsholing two floor dwelling populations were estimated using a change-in-ratio method. This was done by measuring rodent activity (percent of inked-boards with rodent tracks) before and after removal (trapping) of a known number of rodents. That is:

$$\frac{A_1 - A_2}{n} = \frac{A_1}{N_1} = \frac{A_2}{N_2}$$

Where n is the number of animals removed, N_1 is the population before removal, N_2 after removal, A_1 is the percent of active (tracked) boards before removal, and A_2 the percentage of active boards after removal.

In Phuntsholing store No. H-3, approximately 412 m^2 of floor area were actively used for sacked wheat and sacked, dry milk. The wheat stores occupied about 175 m^2, and wheat had been in storage for about 8 months, while the dry milk had been stored about 3 months. Both wheat and dry milk were on pallets and stacked to about 3-4 m high. Rodent signs were abundant around the wheat, indicating a severe infestation. The change-in-ratio population estimation was that 190 animals were active on the floor surrounding the wheat. There was little rodent sign around the dry milk, suggesting that there was at least one rodent per square meter under the wheat. There were probably at least as many additional animals living in and above the floor that could not be estimated. In Phuntsholing store No. 6, the visual survey indicated a moderate infestation. The change-in-ratio estimation was 4 animals under sacked and palleted pulses, occupying an area of about 46 m^2, or 10.6 m^2 per animal; again, there probably were another 8-10 animals above the floor and thus beyond our sampled area. Since the mouse traps used were generally ineffective, comparisons of the numbers of droppings and sightings suggest that mice were at least 10 times more abundant than rats.

Table 2. Rodent infestation data.

Location	Structure Condition	Commodities	Capacity (Mt)	Estimated[a] Infestation
Phuntsholing	Good	Grain; dry milk	800	Severe
	Good	Pulses	200	Moderate
	Good	Oil	70	None
	Fair	Vegetables	420	Moderate
	Good	Fruit	Unknown	Moderate (seasonal)
	Good	Grain	175	Severe
	Good	Grain	200	Moderate
Thimphu	Good	Grain	140	Moderate
	Good	Grain	160	Moderate
Tongsa	Fair	Grain	30	Severe
Gaylegphung	Poor	Grain, salt	30	Severe
	Good	Grain	12	Moderate
	Poor	Grain	50	Severe
	Fair	Grain, pulses, salt	300	Severe
	Poor	Grain	250	Severe
	Fair	Salt, oil, sugar	100	Moderate
	Fair	Oil	150	Moderate
Damphu	Good	Grain	250	Severe
	Good	Grain	130	Severe
	Good	Grain	40	Moderate

[a] Estimation of infestation based on density of droppings, amount of visible damage, and sightings of rodents.

Several conditions in the structures significantly influenced the magnitude of infestations. These conditions were: (1) the duration of storage of a given lot, (2) the amount of human activity in and around the stores, (3) the condition of the storage structure, and (4) the sanitation conditions in and around the storage structure, i.e., rodent harborage. Our surveys suggested that rodents consume about 70 Mt of FCB grain each year and they also contaminate an additional 700-1,400 Mt of all grain at current storage capacity of 27,000 Mt. This estimate of grain consumption by rodents in FCB storage structures is based on several assumptions: (1) that the storage structures sampled were representative of those not examined; (2) that the change-in-ratio method of population estimation measured only those animals active on the floor at the peripheral areas around the stored grains and that these estimates are only valid for rats, since mouse traps were almost generally ineffective; (3) that the *M. musculus* population was estimated by droppings and sightings and that their densities were 10 times greater than rats; (4) although storage periods of specific grain lots vary in duration, there is always about 2,250 Mt of grain in storage during the year; and (5) that the mean food consumption data based on average weight of the rodents trapped (Table 3) is representative for those species.

Table 3. Estimated individual consumption of FCB commodities by 4 rodent species trapped in Bhutan.

Species		Average wt (g)	Average[a] daily consumption (g)	Average consumption per storage year (k)
B. bengalensis		211	21.1	7.6
R. rattus		98	9.8	3.5
R. norvegicus		273	27.3	9.8
	$\bar{X}$	194	19.4	7.0
M. musculus		17	2.5	0.9

[a] Rats consume an average of 10% of their body weight daily, while mice consume about 15% of their body weight daily.

HEALTH HAZARDS

Rodents are primary reservoirs for numerous diseases which are transmissible to man (Gratz, 1988). These pathogens include bacterial, rickettsial, viral, protozoa, and arthropod organisms. Although a description of each disease transmissible to man and domestic animals from rodents is beyond the scope of this report, a brief description of the more common ones follows:

1. Leptospirosis, also called infectious jaundice, is transmitted in rodent urine. Fatalities are high in young and old patients. This disease is often difficult to diagnose, even with good diagnostic facilities.

2. Salmonellosis, commonly known as infectious food poisoning, is a disease that can be transmitted by rodent-contaminated food or liquids. The house mouse, *M. musculus*, is a very common carrier of this group of disease organisms. This disease can be fatal, particularly in children.

3. Plague, the Black Death epidemic of the 14th Century originated in Asia and swept across the Middle East and Europe killing thousands of people daily. World Health Organization (WHO) data for 19 counties including India and Burma ranged from 1,000 to 3,000 diagnosed plague cases annually over the past decade. There are many undiagnosed cases of plague. The rat flea transmits the bacillus *Yersinia pseudotuberculosis* to man. During this mission, a serious plague outbreak was reported in Assam, India.

4. Other important rodent-borne diseases include: rickettsialpox, haemorrhagic fevers, rat-bite fevers, trichinosis, lymphocytic choriomeningitis, murine typhus, and intestinal parasites, such as tapeworms.

Hazards resulting from rodent infestations in FCB storage facilities could easily present excessive health risks. In general, there is no doubt that many illnesses and deaths are the result of rodents and their contamination of these commodities. In Bhutan, the lack of diagnostic and health care facilities probably obscures the rodent-related diseases and mortalities.

COUNTERPART TRAINING

Mr. Chimi Dorji accompanied me during each phase of this mission. He received instruction and participated in rodent identification, population assessments, trapping techniques, rodent-proofing structures, sanitation, and general rodent control methods.

RECOMMENDATIONS

1. Training of FCB (and extension personnel) is the most basic and pressing need since Bhutan has no history of rodent control. This should be accomplished by a series of instructions and practical exercises. One individual in FCB should be in charge of vertebrate pest control in FCB storage facilities. This individual should have extended training.

2. Upgrading of some FCB storage facilities is needed. FCB owns or leases a number of storage facilities, many of which are in good condition (see Table 2). Those would require only minor structural modification to prevent rodent entry (e.g., an elevated loading dock at each door). Other older structures (mostly leased) are not suitable for grain storage. These would require extensive rehabilitation, such as new floors, doors, and other rodent-proofing improvements.

3. Increased sanitation measures are needed in and around storage structures to eliminate rodent harborage. This may be as simple as a weekly cleanup schedule.

4. Some research is needed to determine the most culturally suitable and effective control methods for Bhutan, e.g., trap type, trap baits, and trap placements for each species. In many instances, simple rodent traps may be adequate. Research should also include an evaluation of first generation anticoagulants, such as warfarin in a water carrier, because chemicals may be of use in some situations. However, with the abundant food in storage facilities, rodent acceptance of food-based baits probably will not be satisfactory.

5. Finally, an ongoing rodent control program in FCB storage structures is needed and should be implemented based on the findings from research.

The proper implementation and continuation of these recommmendations most likely would greatly reduce the rodent infestations by up to 90% in FCB storage facilities. The cost of rodent-proofing structures is minimal and would be returned in a short time in grain saved from rodents. The health benefits from the program recommended would be substantial. A proposed technical assistance project to increase food supplies in FCB storage facilities follows.

PROJECT DOCUMENT PROPOSAL FOR RODENT CONTROL IN FOOD CORPORATION OF BHUTAN STORAGE FACILITIES

I. Project Summary (to be completed by FAO)

II. Background and Justification

There is no historical precedent for rodent control in Bhutan. Consequently, the Food Corporation of Bhutan (FCB) requested FAO assistance in problem definition, training, and recommendations for rodent control in FCB stores. The FCB is a department of the Ministry of Agriculture of the Royal Government of Bhutan. The functions of FCB are transport, storage, and wholesale distribution of foods. These foods consist primarily of grains (rice, wheat, and maize), potatoes, fruit, salt fish, salt, and other miscellaneous items. FCB also transports, stores, and distributes World Food Program (WFP) stores.

The FCB currently handles about 27,000 Mt of grain annually. This amount is expected to increase to over 60,000 Mt in 1989. This will amount to about 33% of the national cereal production of an estimated 182 Mt (FAO, 1986). The 1989 increase is expected to consist primarily of maize. Maize is currently exported and it is anticipated that low cost and availability of local maize will decrease the importation of rice.

The FCB now has storage capacity for about 7,800 Mt of food of which about 3,500 Mt is used for grain storage (this figure includes WFP commodities). Additional FCB grain storage facilities will be needed in 1989. Grains and other foods may be in storage for periods ranging from 1 week to many months.

Rodents found to be damaging, consuming, and contaminating FCB food commodities were the black rat (*Rattus rattus*, the brown rat (*Rattus norvegicus*), the bandicoot rat (*Bandicota bengalensis*), and the house mouse (*Mus musculus*). The Asiatic house shrew (*Suncus murinus*), an insectivore, was also abundant in some areas. Infestations ranged from moderate to severe, with the house mouse being the most widely distributed and abundant pest species. These rodents consume an average of about 3-4% of the foods, primarily grains, in FCB storage structures. They contaminate an additional 10-20% of these foods. Health hazards from rodent contamination are extremely high. The rodent species composition and the degree of infestation are dependent on the duration of storage, the condition of the storage structure, and the sanitation (rodent harborage) in and around the storage structure.

III. Objectives of this Assistance

Since Bhutan has no history of rodent control, a small amount of research and an agressive training package should be components of any future assistance efforts. Training of select FCB personnel in rodent identification, biology, and behavior, rodent exclusion methods, sanitation, health hazards created by commensal rodents, and rodent control techniques are most pressing and basic objectives. Personnel trained should include: a counterpart, a manager in the Quality Control Section (QCS), and managers from each of the four regions and four subregions. Although agricultural extension and health services personnel are not a part of FCB, they would also benefit greatly from training.

One individual in FCB should be appointed and placed in charge of all vertebrate pest control in FCB stores. This individual should receive extended training, preferably in vertebrate pest control at one of two qualified institutions in the United States. This would insure that a qualified individual is in charge and that this individual is capable of training and directing rodent control operations in a safe and effective manner when the period of FAO technical assistance has terminated.

The storage structures owned by FCB are generally of excellent design and condition. Minor structural modifications, such as elevated loading docks at each entrance, would greatly reduce the rodent access into the structures. Design assistance for these modifications should be available to the Construction Section of FCB.

An ongoing rodent control program in all FCB storage structures is urgently needed. To be effective, this program should be designed to meet the needs to control each rodent species in the various situations which exist in short- and long-term storage conditions. It is anticipated that the methods and tools used in this program will range from simple spring-type and multiple catch traps to the use of rodenticides. However, some short-term applied research is needed to determine the most culturally suitable and effective control methods for FCB storage facilities in Bhutan. Among the objectives that need to be addressed are to determine the most useful trap baits, trap types, and trap placements. First-generation anticoagulants, such as a water soluble salt of warfarin, should be evaluated as a possible control tool in some situations, since food based toxic baits are usually poorly accepted in storage facilities where an abundance of food is available.

The implementation and continued application of these objectives should result in a reduction of up to 90% in the rodents infestations in FCB storage structures. The costs would easily be returned by the grain and other commodities saved from rodent consumption and contamination. The health benefits derived from these measures would be enormous.

Objectives in chronological order:

1. Provide training to FCB personnel in rodent biology, population estimates, damage assessments methods, health hazards, and control methods. This would consist of a 3-week course providing basic knowledge and field exercises in these subjects. Selection is needed of one individual with a B.S. Degree to be in charge of vertebrate pest problems in FCB storage structures. This individual (with above training) would receive additional training at Colorado State University, Fort Collins, Colorado, USA, or Utah State University, Logan, Utah, USA, or another institution leading to a Masters of Science Degree, specializing in agricultural vertebrate pest control.

2. Initiate research and evaluations to determine the most culturally acceptable and effective rodent control methods in several geographical areas of Bhutan as they relate to rodent species, storage structure types, and duration of storage of principal cereal grains.

3. Assist the Construction Section of FCB Technical Services Subdivision in design of rodent-proofing modifications to existing storage facilities and designs that should be incorporated into new storage structures.

4. Initiate a countrywide rodent control program designed to increase food supplies in FCB storage facilities by providing safe, effective, materials and methods to reduce rodent consumption and contamination of stored foods.

5. Monitor the progress of the project at regular intervals by estimating rodent populations in FCB storage structures and making timely changes or adjustments in the project.

IV. Work Plan and Inputs

The Denver Wildlife Research Center (DWRC) in Denver, Colorado, USA, can also provide research expertise and practical training and experience by short-term consultancies in Bhutan in rodent biology and control. The training offered is flexible to accommodate special interests and can be expanded to include other aspects of rodent control, if desired. Colorado State University at Fort Collins, Colorado, USA, or Utah State University at Logan, Utah, USA, can accommodate foreign students in special programs in vertebrate pest control.

DWRC can also provide personnel to initiate the research and evaluations needed to develop an acceptable, safe, and effective rodent control program in FCB storage structures. DWRC can provide guidance in rodent-proofing of structure and intitiation and monitoring of the countrywide rodent control program. However, the success of the project will, in large part, depend on the participation and continuation of the initiatives by FCB personnel.

A. FAO will provide funds for the following:

1. Technical Expertise

Experts for six consultancies of about 1 month each over the next 4 years. The expert will train and work with counterparts in research and evaluations of rodent control methods; initiate and monitor a countrywide rodent control program in FCB storage facilities; make timely adjustments to the project; and advise on a long-term rodent control program as new information is determined.

2. Equipment and supplies, as needed

	Date	Estimated Cost (US$)
Traps of various designs for evaluation	8/89	1,000
Traps selected for operational control	8/90	5,000
Rodenticides	8/89	3,000
Miscellaneous supplies and equipment	8/89	1,000
Vehicles and fuel	8/89-11/92	4,000
Training and instructional manuals	8/89-11/92	2,000

3. Training

Several Bhutanese should be sponsored to attend the Vertebrate Pest Control short course (August 1989) at Colorado State University, Fort Collins, Colorado, USA.

One Bhutanese should be sponsored for a 2-year study program leading to a Masters of Science Degree in vertebrate pest control to agriculture at Colorado State University or Utah State University in Fort Collins, Colorado, USA, or Logan, Utah, USA, respectively.

B. The Royal Government of Bhutan will provide:

1. Appropriate local staff for training, and those trained will provide training to subordinates.

2. One senior counterpart; 2-4 staff; 2 drivers and causal labor, as required.

3. Administrative support staff, including a secretary.

4. The general provisions for operation of the project, including travel and expenses for trainees and staff, as required.

5. A classroom and equipment storage areas.

VI. Reporting

Progress reports will be prepared by the short-term consultant after each trip as well as a final report submitted to the Royal Government of Bhutan, to include long-term recommendations to guarantee the continued operations of the project. During the 11 months of each year when the adviser(s) is not in Bhutan, any reports, including semiannual, specific project reports, training manuals, or extension materials will be supplied to FAO and the Royal Government of Bhutan.

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APPENDIX I

ITINERARY

Date	Location	Activity
September 26-30	Denver, Colorado, to Thimphu, Bhutan	Travel and FAO briefing
October 1	Thimphu to Phuntsholing	Travel
October 2-10	Phuntsholing	FCB briefing, survey stores, species identification, and population estimates
October 11	Phuntsholing to Thimphu	Travel
October 12-14	Thimphu	Survey stores and species identification
October 15	Thimphu to Tongsa	Travel, survey stores, and species identification
October 16	Tongsa to Gaylegphung	Travel
October 17-18	Galegphung	FCB briefing, survey stores, and species identification
October 19	Gaylegphung to Damphu	Travel, survey stores, and species identification
October 20	Damphu to Thimphu	Travel
October 21	Thimphu	FAO briefing and report writing
October 22	Thimphu to Paro	Travel and counterpart briefing
October 24-26	Paro, Bhutan, to Denver, Colorado	Travel

APPENDIX II

CONTACTS AND ACKNOWLEDGMENTS

Royal Government of Bhutan, Ministry of Agriculture

Dasho Khandu Wangchuk, Director General
H. J. Nepal, Managing Director (FCB)
Kinlay Tshring, Deputy Managing Director of Operations (FCB)
Nagtong Dukpa, Depu[illegible] Manager (FCB)
Chimi Dorji, Senior Manager (FCB)
Ganesh Gurung, Senior Manager (FCB)
Burma Dukpa, Regional Manager (FCB)
Singay Dorsi, Assistant Manager (FCB)
K. B. Ghalley, Manager (FCB)

FAO, Bhutan

Reinhard Breitbart, Programme Officer
Richard Anthony, Pest Control Specialist
Larry Hasting, Cost Accountant

INTERIM REPORT: ENVIRONMENTAL ASSESSMENT
LOCUST CONTROL PROGRAM--SENEGAL

C. Edward Knittle
Environmental Specialist
Denver Wildlife Research Center
USDA/APHIS
Denver, Colorado

1 November 1988

Objectives:

Environmental Assessments:

Pesticide storage, handling, and disposal procedures.
Potential human health problems.
Nontarget wildlife effects.
Logistics and tasks for my successor.
Recommendations.

1. Pesticide Storage, Handling, and Disposal

During my 2½ weeks in Senegal, I took the opportunity to observe several situations involving this topic. The first was the Canadian aerial application team, Agric-Air, operating out of the St-Louis Airport. Their ground support team consisted of Senegalese formerly trained in pesticide operations; most are previous hires by Agric-Air (the same procedure is followed by most other contractors). Each pesticide handler was properly clothed in splash-suits, canister-type breathing masks, and rubber gloves and boots; no one was wearing eye protection. Each aircraft was also equipped with a canister-type breathing device within easy reach of the pilot. The Canadian operation was very efficient, orderly, and safety conscious.

During my visit to the French/FAO operation at the Dakar Airport, the ground support crew expressed concern they did not have chemical splash-suits even though they had requested them. Most were wearing rubber boots and gloves, and dust masks (no eye protection) during cleanup operations. The aircraft were idle and the ground crew indicated they were moving pesticides (malathion) to a new location to begin another spray operation.

The majority of my observations involving pesticide handling, etc., revolved around the Senegalese Crop Protection Service (CPS). My findings and recommendations are contained in a letter to the CPS Director, Dr. Mouhammadou Ly (Appendix A).

At each pesticide handling site I visited, I saw no evidence of availability of an emergency water source/water bath in case of accidental pesticide contamination to workers. I was, however, told that this was available.

Disposal of pesticide containers (including bags for powdered pesticides) appears to be somewhat lax for most operations. The Canadian team indicated their empty barrels are supposedly removed by an independent agent and returned to Dakar. Unfortunately, empty pesticide barrels (not necessarily those from the Canadian operation) frequently appear in towns and villages as water containers. Unless one can be assured that barrels are being reused for pesticides or are properly cleaned before other uses, barrels should be punctured and/or crushed when emptied to eliminate their use as water containers or for other nonpesticide purposes. Pesticide bags, likewise, remain in the hands of farmers for storing harvested grain. As useful as they are, these bags should be destroyed after pesticides have been removed.

The American aerial-spray contractor had not yet arrived in Senegal as of the date of this report. However, one of the tasks of my successor, Dr. Richard Dolbeer, will be to evaluate this operation in the Senegal River Basin.

2. <u>Other Human Exposure Problems</u>

The risk of pesticide exposure to human inhabitants (and to a lesser extent domestic livestock occupying the savanna in locust-infested areas is ever-present. I was told by the CPS that radio broadcasts were frequently issued explaining locust control spray operations and what to do if spray aircraft are sighted. Villagers are told to remain in their residences, if possible, during overhead spray operations. I doubt the effectiveness of this procedure given that many small villages do not have access to radios. However, word travels fast in the bush by word of mouth, so, in fact, warnings may be passed on to a majority of the populace by this method.

If feasible, aerial applicators should be encouraged to momentarily shut off spray equipment when overflying villages or other congregations of human inhabitants. Villagers should also be encouraged to wash harvested food items before consumption.

When practical, farmers are involved in a self-help program for controlling locust infestations in small, localized areas of cropland. Powdered pesticides, usually fenitrothion (2.5%) or propoxur (2.0%) are provided by the CPS with instructions for proper use. Occasionally, minimal protective items, such as dust masks, are also supplied. I observed one farmer covered with white dust; he was returning from a field where he had applied a powdered pesticide. Even though the risk of intoxication is low, given the small amount of active ingredient in powdered pesticides, many farmers do not comprehend the potential risk of this continuous type of exposure even when provided with use instructions. The paradox here is that farmers are very motivated to this self-help program. It is very effective on a small scale and releases the CPS and other applicators to treat larger infestations by air or ground Unimog.

3. <u>Nontarget Wildlife Effects</u>

Of three pesticides being applied by aircraft for locust control, carbaryl is far the safest, environmentally, followed by malathion. Fenitrothion carries a much higher risk to nontargets, particularly avifauna, and should not be applied near water sources. When the American aerial contractor commences work in the Senegal River Basin, the pesticide of choice on newly-emerged irrigated and recessional crops in the basin is supposed to be carbaryl. Even with the diversity and abundance of bird species in the river basin area, and given that proper application rates are used, one would not anticipate any adverse effects on wildlife, including fish, from carbaryl.

Within the proposed area to be treated by the American contractor lies Parc du Djoudj. This park harbors a plethora of resident bird species and newly arriving migrants from the north. In addition, the tourist season in the Park begins November 1, which means ornithologists and bird-watchers will frequent the area. I would recommend a nonspray buffer zone around the Park of at least 1 mile (1.6 km). The same buffer zone should be observed near any other water source unless the infestation is overwhelming within this zone. If so, minimal aircraft applications should be close to the ground to minimize drift.

Although a major portion of locust-infested area is yet to be treated, I made a few cursory observations of savanna-land recently treated with fenitrothion (0.5 L/ha) by the Canadians. There were no obvious adverse effects noted on nontarget wildlife. The Canadians are very aware of the potential for bird problems if fenitrothion is not properly applied.

4. <u>Logistics and Tasks of Incoming Environmental Specialist</u>

I will recommend to the new Environmental Specialist, Dr. Richard Dolbeer, USDA, Denver Wildlife Research Center, that he:

a. operate out of St-Louis or Richard Toll;
b. assess the pesticide safety procedures of the American aerial application contractor;
c. concentrate most of his pre- and posttreatment nontarget wildlife surveys on avifauna in the Senegal River Basin;
d. make a more definitive evaluation of nontarget wildlife exposed to fenithrothion when and where used; and
e. report his findings, in writing, at the conclusion of his evaluations.

5. Summary Recommendations

a. Provide emergency water sources/water baths for pesticide handlers in storage and handling depots and at aircraft operation sites.
b. Provide chemical splash-suits and eye protection to all pesticide handlers.
c. Assure that empty pesticide containers are properly disposed of or rendered useless.
d. Avoid, when practical, direct-spray applications to villages and human inhabitants.
e. Encourage villagers to wash food items before consumption.
f. Improve and increase awareness of safe pesticide handling procedures to farmers applying powdered pesticides.
g. Provide as much safety equipment as practical to farmers using powdered pesticides.

cc: DIR: S. J. Littlefield
DDIR: G. Carner
ADO: D. Robinson
IWME: B. Egan

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APPENDIX A

(Excerpts of letter from Knittle to Dr. Mouhammadou Ly, Director, Crop Protection Service; dated October 31, 1988)

On the subject of pesticide application, storage, and handling, I would like to share my observations with you.

1. Unimog operations: Each Unimog application team was making a reasonable effort toward safety precautions while applying pesticides. Each applicator was wearing a respirator or dust mask, rubber gloves and boots, and a chemical splash-suit; no one was wearing eye protection. My biggest concern is for the drivers of the Unimogs. None was wearing any protective equipment. Occasionaly there was spraydrift during an application which enveloped the driver, thus creating a potential toxicity hazard to him. Otherwise, operations and personal protection appeared adequate.

2. Pesticide storage: During my brief inspection of the pesticide storage depot at the Dakar CPS compound, I found storage facilities and handling procedures in reasonably good order. However, there were four situations I observed which I would like to bring to your attention.

   First, in the area where powdered pesticides and treated grain-baits are stored, there was considerable spillage on the floor from damaged bags. With the powdered pesticides, I am concerned that movement of these powders by wind currents can create a subtle, but frequent exposure to your staff within your compound and in adjacent areas. Moreover, personnel working in the storage area were walking through these residual powders in sandals, thus causing an unnecessary exposure risk to workers. These powders should be removed, placed in plastic bags, put into a metal container and buried in a ground pit. The disposal pit should be in an area where groundwater will not be affected.

   Secondly, a number of labels were missing from pesticide barrels. This problem can cause unfortunate errors in determining which kind of pesticide is contained in these unmarked containers and may cause improper application or application rates, if used.

   Thirdly, I observed a few barrels that were leaking. The contents of these barrels should be placed in a new barrel and sealed with the proper labeling on the outside. The emptied barrels should be punctured and crushed so they cannot be used, then burried in a ground pit as explained above.

   Finally, I asked, and was told, there is a complete medical facility and doctor near your facilities to treat personnel involved in emergency pesticide exposures. I would like to also suggest that a water bath or water source be made available within the storage compound in case of accidental contamination to workers from spilled pesticides.

3. **Pesticide application by farmers:** I observed one farmer near St-Louis who was completely covered with white powder following his application of a pesticide. Even though I have been told that farmers are instructed in the proper handling of pesticides and that they may be provided with minimal safety items, here is one example where the system has failed. The unnecessary exposure of farmers who improperly handle pesticides may cause a potential illness problem and possibly an unfavorable outlook on locust control operations.

Summary of corrective recommendations:

1. Frequently clean up and properly dispose of powdered pesticides and treated-bait spillage in storage compounds.
2. Request that workers wear dust masks or respirators and rubber boots when working in or handling pesticides in storage areas.
3. Label unmarked pesticide barrels.
4. Properly dispose of leaking barrels after the contents have been placed in new, labeled containers.
5. Provide Unimog drivers with respirators and safety clothing.
6. Provide eye-protection for pesticide applicators and handlers.
7. Provide emergency water source in case of accidental contamination of pesticide handlers.

These recommendations require only a little extra effort, but can provide a much safer pesticide storage and handling environmental which would minimize hazards to personnel.

1793G

TRIP REPORT*

PROJECT PLANNING, GROUNDNUT RODENT DAMAGE ASSESSMENT, AND WILD BOAR RESEARCH

PAKISTAN

October 14-November 8, 1988

Lynwood A. Fiedler

International Programs Research Section

Denver Wildlife Research Center

Animal and Plant Health Inspection Service

U.S. Department of Agriculture

Denver, Colorado USA

Unpublished Report

December 5, 1988

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SUMMARY

Through discussions with the U.S. Agency for International Development (USAID), the Vertebrate Pest Control Project (VPCP) staff, the Vertebrate Pest Control Laboratory (VPCL) in Karachi, Faisalabad University cooperators, and the Project Leader, plans were developed that would best serve the animal damage control needs of Pakistan within the constraints recently proposed by USAID. A method for experimentally assessing rat damage in mature groundnut fields was provided, and plant samples from one field with rodent burrows were collected. Meetings were held with several graduate students and their faculty advisers at the University of Agriculture, Faisalabad, and suggestions were offered for their planned research activities. Assistance was given to the project in wild boar trapping and collecting activities near Fateh Jhang and Faisalabad as well as in assembling and testing some radiotelemetry equipment for tracking wild boar.

OBJECTIVES

The primary purpose of this assignment was to assist the Project Leader of the USAID/Denver Wildlife Research Center (DWRC)/VPCP in defining the future of the project. VPCP also requested a protocol for assessing rat damage in mature groundnut fields and suggestions regarding planned research activities for graduate students at the University of Agriculture, Faisalabad. Another purpose was to assist the project in wild boar research activities at Fateh Jhang and Faisalabad.

BACKGROUND

DWRC assistance in Pakistan began in 1985. Short-term assignments related to project planning and defining specific vertebrate pest problems were completed. Joe E. Brooks, Team Leader, VPCP under the USAID Food Security Management (FSM) Project, arrived October 1985 to implement research and training on postharvest losses caused by rodents and birds. A preharvest vertebrate control component was added when these losses were found to be much more significant in Pakistan.

Present objectives of the project, due to terminate in June 1990, include:

1. Strengthening the four Provincial Food Departments in assessing and controlling postharvest losses.

2. Strengthening the Pakistan Agricultural Storage and Services Corporation (PASSCO) in assessing and controlling postharvest losses.

3. Improving the quality of adaptive research.

4. Assessing postharvest losses at the farm level and devising control methods.

5. Strengthening the Pakistan Agricultural Research Council (PARC) vertebrate pest control programs located in Karachi and Islamabad.

6. Assessing preharvest losses and developing control methods.

Accomplishments to date include:

1. Conducted a survey of 349 provincial food departments and 146 PASSCO facilities quantifying vertebrate postharvest losses.

2. Made initial surveys of wholesale commodity markets in the Punjab to define vertebrate postharvest losses.

3. Conducted initial surveys of on-farm losses of stored foods near Faisalabad.

4. Formulated plans to test control methods.

5. Trained 371 persons and developed a training manual and materials.

6. Surveyed preliminary preharvest damage in wheat, maize, sugarcane, and groundnut.

7. Tested preharvest control methods in several locations.

The main findings to date are that vertebrate pest damage to wholesale and retail stored grain amounts to 1-2% plus an additional 0.5% due to spillage and contamination. On-farm storage losses may prove to be much greater. Preharvest losses are much more significant, and a greater emphasis should be given to vertebrate damage in field crops.

ACCOMPLISHMENTS

Project Status

Whether the project should be managed with a resident biologist or by several temporary duty assignments (TDY's) until the completion date (June 1990) was evaluated. Through consultations with the USAID/National Agricultural Research Centre (NARC)/DWRC/VPCP staff, USAID/Agricultural and Rural Development (ARD) staff, Pest Management Research Institute (PMRI)/VFCL staff in Karachi, FSM/Storage Technology Development and Transfer (STDT) in Lahore, and the University of Faisalabad faculty and graduate students, the conclusion was reached that the project must be staffed with a DWRC resident biologist for the duration of the current project period. Without a resident biologist, two major objectives of the postharvest work would be jeopardized: (1) completing the training materials and training courses and (2) quantifying on-farm stored food losses which may be a significant problem requiring a recommended control method.

More at risk, however, due to the potential gains, is the need for solutions to the primary preharvest vertebrate pest crop losses that have been identified. Two problems, rodent damage to wheat and rodent damage to rice, appear to have been researched enough that recommendations are ready for field demonstrations. Annual losses by rodents in Pakistan in these two crops alone are estimated to be about U.S. $117 million (see Table 1). Secondly, wild boar damage to sugarcane, wheat, and maize annually amounts to about U.S. $127 million. There is currently no safe, effective method to control wild boar damage. Initial research, however, has provided some information that indicates a practical solution to this problem is possible. A major research effort will be required during the next 12-18 months.

The VPCP unit at NARC is not yet established, leaving no assurance that the management of the project by TDY's would be carried out efficiently. The resident biologist currently carries out this function. Trying to handle this with existing counterpart staff and TDY's from DWRC would overly burden USAID with the additional management duties.

Furthermore, local counterpart staff will be reduced by two, due to degree training abroad. Accomplishing the above preharvest objectives will require a maximum effort by a resident biologist. To rely on TDY's would require time beyond the current project expiration date (June 1990) and would preclude work on two other significant bird pest problems - parakeet damage to maize (estimated at U.S. $11 million annual losses) and house sparrow damage to wheat (estimated at U.S. $34 million annual loss).

Finally, the cooperative program at the University of Agriculture, Faisalabad, will lead to a self-sufficient, on-going vertebrate pest curriculum and research program in about 2 years. Financial and technical support now supplied by the project and resident biologist, respectively, have been extremely and mutually beneficial. Administrative and technical assistance could not be facilitated well through TDY's at this stage of development.

Rat Damage Assessment in Groundnut

Unusually late rains prevented or delayed entry of rodents into most groundnut fields. This obviated any large-scale effort to use rat-damaged fields to collect data that would be useful toward developing an assessment technique. However, one groundnut field with rodent burrows was located near Channi Village. On October 27, we marked off a 90-m^2 rat-damaged area and a 90-m^2 undamaged area within a 625-m^2 field. Fifteen 1-m^2 quadrats were randomly selected from each area, and whole plants were removed, bagged, labeled, and brought to the NARC lab for washing, drying, weighing, and counting. Total plants in each area were counted, and burrow systems were mapped and dug up to determine if cashing was being done by rodents. Project staff will finish drying and recording data on collected plants. Results should provide some insight for planning damage assessment field work in groundnuts next September/October.

Table 1. Primary preharvest vertebrate pest problems and their estimated annual losses in Pakistan. Hectarage, yield, and value from Pakistan Statistical Yearbook, 1986. Question mark in estimated loss column means no reliable damage data are available.

Pest	Crop	Total ha (millions)	x	Yield/ha (metric ton)	x	Estimated Loss (%)	=	Total loss (metric ton)	Value (rupees) per 40 kg	Loss value U.S. $ (million)[1]
Rats and mice	Wheat	7.2585		1.6123		3.5		409,601	82	52.8
Rats and mice	Rice	1.9985		1.6588		8.0		265,209	155[2]	64.6
Wild boar	Sugarcane	0.9036		35.5684		7.5		2,410,470	10	37.9
Wild boar	Maize	0.8088		1.2705		6.7		68,848	94	10.2
Wild boar	Wheat	7.2585		1.6123		5.2		608,550	82	78.5
Rats and mice	Sugarcane	0.9036		35.5684		1.75[3]		562,443	10	8.8
Parakeets	Citrus	0.1362		9.5470		8.6		111,826	137	24.1
Parakeets	Maize	0.8088		1.2705		7.5		77,069	94	11.4
Parakeets	Sunflower[4]	0.0455		0.8307		15.7		5,934	170	1.6
Pika	Apple orchards	0.0133		9.6316		2.0		2,562	473	1.9
Porcupine	Forestry, irrigated	0.0239		-		20.0		-	-	0.6
Porcupine	Maize	0.8088		1.2705		0.4		4,110	94	0.6
Porcupine	Potatoes (other vegetables not included)	0.0632		9.8908		2.0 ?		12,502	100	2.0
House sparrow	Wheat	7.2585		1.6123		2.26		264,485	82	34.1
Voles	Apples	0.0133		9.6316		2.0		2,562	473	1.9
Rats	Groundnut	0.0591		1.1692		3.0 ?		2,073	282	0.9
										331.9

[1] Exchange Rs 15.9 = $1.00 (1985).

[2] Derived from hectarages and values for three rice groups commonly grown.

60% IRRI variety 109 Rs/40 kg
30% Basmati variety 235 Rs/40 kg } 155 Rs/40 kg
10% Other variety 191 Rs/40 kg

[3] Derived from 9.2% stalk damage and an estimate of 19% weight loss per stalk.

[4] 1986/87 Oilseed Project Data.

Wild Boar Research

Field work on wild boar was initiated earlier this year. Populations of wild boar are being characterized through collection of animals, aging, sexing, weighing, and determining reproductive condition. Movement and home range will soon be studied to assist in developing wild boar control recommendations. Radiotelemetry equipment on hand was examined. Three Yagi antennae were assembled and one wild boar radio was activated and the range determined to be about 5-6 km under adverse conditions. A mortality radio was activated, made stationary, and found to signal mortality within 4 h of inaction.

Trapping activities near Fateh Jhang were observed and some suggestions made to improve the methods. Wild boar had damaged about 5% of maturing sorghum which was 7-10 days from harvest.

I assisted project personnel and cooperators at Faisalabad in collecting three specimens of wild boar (2 males, 113 and 56 kg; one female, 75 kg) for autopsy and measurements.

ITINERARY

Date	Location	Activity
October 14-16	Denver, Colorado, to Islamabad, Pakistan	Travel
October 17	Islamabad	Met with USAID/ARD and NARC/VPCP staff.
October 18	Islamabad to Karachi	Radiotelemetry equipment testing; Food Security Management Team meeting; travel.
October 19	Karachi	VPCL/PMRI staff visit; facilities tour; activities discussed.
October 20	Karachi to Islamabad	VPCL activities and plans reviewed; travel.
October 21-28	Islamabad and vicinity	VPCP project planning; groundnut area near Channi Village sampled for rat damage; wild boar study area near Fateh Jhang visited.
October 29-31	Islamabad to Karachi and return	VPCL/PMRI visited; vertebrate pest activities reviewed; future preharvest damage research and project planning outlined.
November 1	Islamabad	Consultations, USAID office; VPC preharvest losses summarized.
November 2	Islamabad to Lahore	Travel; postharvest training materials presented to FSM/STDT Training Center; met with Dr. Cheema, Department of Zoology, University of the Pubjab.
November 3	Lahore to Faisalabad	Travel; met with Mohammad Hafiz Khan and Dr. Mirza A. Beg.

Itinerary (Continued)

Date	Location	Activity
November 4	Faisalabad	Wild boar damage examined; three animals collected and autopsied.
November 5	Faisalabad to Islamabad	Consultations with Beg and Khan regarding graduate research and curriculum; travel.
November 6	Islamabad	Report writing; USAID debriefing.
November 7	Islamabad	Flight canceled; new itinerary arranged; groundnuts dried and weighed.
November 8	Islamabad, Pakistan, to Denver, Colorado	Travel

CONTACTS AND ACKNOWLEDGMENTS

Islamabad

USAID

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Mr. Thomas Olson, Project Officer, Economic, Marketing, Planning Assessment Section (EMPAS), ARD
Dr. Zakir Hussain Rana, Program Specialist, EMPAS, ARD
Mr. Ejaz Ahmad, Research Specialist, VPCP, ARD/NARC
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APPENDIX I

INSTRUCTIONS FOR HANDLING GROUNDNUT PLANT MATERIAL COLLECTED FOR DAMAGE ASSESSMENT

Maintain each sample by number* throughout procedure.

1. Wash soil off plants.
1a. Count number of plants in bag.
2. Remove any weeds.
3. Dry whole plants (until no further weight loss occurs).
4. Measure total weight.
5. Clip plant approximately at ground level.
6. Weigh bottom, or root, portion.
7. Count number of shells.
8. Weigh shells only.

9. Record data.

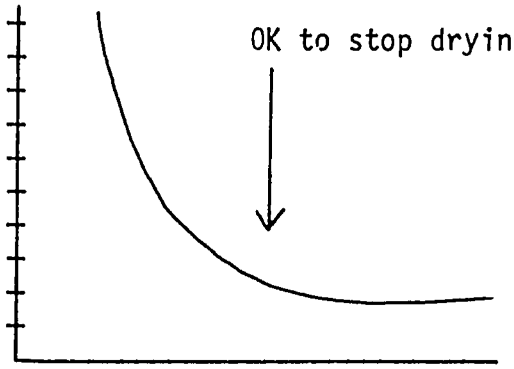
	Number of plants	Total weight	Bottom weight	Top** weight	Number of shells	Weight of shells
For each bag						

* Plot 1 tags only have sample number.
Plot 2 tags include "Ref" on each tag.

** Determined from total minus bottom weight.

OK to stop drying (no or little additional weight loss)

Wt.



Time (hours)

First batch, monitor closely; set temperature to 60° C and adjust if too hot (we don't want to roast the nuts, just dry them).

APPENDIX II

IN-COUNTRY TRIP REPORTS (3)

VERTEBRATE PEST CONTROL PROJECT

Trip Report
October 18-20, 1988

Purpose of the Trip

To discuss with the Director, PMRI, and staff members of the Vertebrate Pest Control Laboratory (VPCL), Karachi, their future workplans and coordination with the VPC Project, Islamabad.

Findings

In several long discussions with Dr. Hafiz Ahmed, Director, and VPCL staff members, it was apparent that they are desirous of working with the VPC Project to institutionalise a Vertebrate Pest Control Research Unit at the NARC, Islamabad. It is also apparent that the present VPCL is situated in the wrong place to truly serve the farmers of Pakistan. One means to help establish an effective unit at NARC would be to have it work closely with mainly a pre-harvest oriented (with a small post-harvest program component), AID-funded VPC project to follow the present project when the FSM Project ends. Some existing technology is developed and in-hand, namely rat and mice control in wheat and rice, and this could be transferred immediately in a large-scale control demonstration involving farmers, agricultural extension workers and members of the private pesticide industry. Other technology still needs research, development and transfer, i.e., biology and control of wild boar, porcupine, parakeet, pika and voles. These problems would take about 5 years to resolve starting in late 1990. To this end, staff of VPCL are preparing a draft PC-1 for circulation and comment. A return visit is planned for 29-31 October to discuss the proposed draft workplans and other documents with the PMRI Director and VPCL staff.

Under Training, Dr. Hafiz Ahmed noted there was one long term vertebrate pest management degree training slot under FSM. He wants to nominate Mr. Shahid Munir for this training. He needs a letter from USAID saying they have the funds to support this long-term training.

Submitted by: Joe E. Brooks and Lynwood Fiedler

VERTEBRATE PEST CONTROL PROJECT

Trip Report
October 29-31, 1988

<u>Purpose of the Trip</u>

A trip was made to the Pest Management Research Institute (PMRI), University of Karachi, to discuss with the Director, Dr. Hafiz Ahmed and Abdul Aziz Khan, a draft 5-year workplan in vertebrate pest control that the PMRI staff are preparing. The several vertebrate pests occurring in Pakistan were ranked in order of importance to establish some workplan priorities. Then the importance of the crops damaged were ranked and matched with the ranked vertebrate pests. A list of 17 priority items was thus identified and a schedule of workplans was drawn up on when each item would be taken up during a 5-year period. Of first and most critical importance was control of rodent damage in wheat and rice which would be taken directly into farmers fields as an operational program during the first 2 years. At the same time, a research and development program was outlined for wild boar control in sugarcane, maize and wheat. Other items would be dealt with during the last 3 years of the workplan schedule. All items would progress through a logical progression of research, development, demonstration and technology transfer. The end result outputs would be developed as technology packages ready for transfer to farmers. The draft workplans will be reviewed again on 6th November in Islamabad.

Submitted by: Joe E. Brooks and Lynwood Fiedler

VERTEBRATE PEST CONTROL PROJECT

Trip Report
November 2-5, 1988

A training package was delivered to Ulysses A. Acasio and Gulzar Qazi at the STDT/FSM Project training facilities on 3 November 1988. The materials consisted of draft Urdu and English grain storage handbooks, a reference manual, leaflets and posters; audio-visual color slide sets with cassette narration in Urdu; stuffed rodents; and one video cassette entitled "The Bad and the Good Godown", narrated in Urdu. These materials are for the use of the Master Trainers in training food storage operational personnel. They will be revised as necessary after receiving the Master Trainers comments.

VPC Project staff will deliver one day of training to the Masters Trainers on 5 December and are planning on having one staff member per week attending the entire training period at the STDT/FSM training facility.

In Faisalabad we met with Drs. Mirza A. Beg and Ali A. Khan, Department of Zoology, and three of their graduate students working on cooperative research. We also met with Mohammad Hafiz Khan, Department of Entomology to review the wild boar research. Hafiz Khan has received 5 graduate students to work under him on M.Sc degrees in applied zoology, i.e., develop and evaluate control methods for vertebrate pests in agriculture. This is being done to fill a need for agricultural workers with a background in vertebrate pest control. Friday was spent in collecting 3 specimens of wild boar for autopsy and measurements.

Submitted by: Joe Brooks, Ejaz Ahmad and Lynwood Fiedler

DRAFT

SUMMARY REPORT: ENVIRONMENTAL ASSESSMENT FOR U.S. LOCUST CONTROL PROGRAM - SENEGAL

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8 December 1988

Introduction: I spent the period 6 - 23 November 1988 in Senegal assessing environmental impacts of the U.S. pesticide spray program for desert locusts (*Schistocerea oregaria*). During my visit, the small planes under U.S. contract (Turbo Thrushes) began their initial spray operations on 8-11 November out of the airport at St. Louis, Senegal. The C130 aircraft then began spray operations out of the Dakar airport on 15 November and one of the DC-7 aircraft followed suit on 20 November. The second DC-7 began spraying on 22 November. The following is a summary of my findings of these spray operations. My itinerary is listed in Appendix I.

This report is a sequel to the interim environmental assessment report filed by C. Edward Knittle on 1 November. Knittle was in Senegal from 16 October - 2 November during which time he observed pesticide handling procedures being used by the Senegalese Crop Protection Service and by contractors from other donor countries.

1. Pesticide handling and disposal, U.S. program

I observed pesticide handling procedures for the small planes (Turbo Thrushes) being used by contractor Robert Ruhe during the period 8 - 11 November at the St. Louis airport. The Senegalese workers used proper clothing and safety equipment in handling pesticides. The main problem I observed was with Ruhe's personnel. They drained the planes' tanks without using gloves or safety equipment, allowing pesticide (malathion) to come in contact with their hands. They also drained malathion into fenitrothion-labeled barrels without changing the label. These practices set bad examples for Senegalese workers.

Another problem noted in St. Louis involved the use of old stocks of malathion from barrels that were in poor condition (rusted and dented). These barrels were probably brought into Senegal in 1986. The contractor did not want to completely drain the contents of these barrels into his aircraft tanks because of fear that residue in the bottom of barrels would clog the spray nozzles. Thus he left 4-8 liters of pesticide in each of the 20 barrels. I had the workers drain each of these barrels for 30 seconds into one barrel, thus consolidating this residue. I then had the workers pour 1-2 liters of diesel fuel into each barrel, agitate the fuel, and drain this for 30 seconds into the barrel with the consolidated residue. I then recommended that the empty barrels be crushed and buried and the consolidated residue in the one barrel be given to the Senegalese Crop Protection Service for use in their Unimog ground sprayers. There are an additional 147 "empty" malathion barrels in poor condition at the Dakar airport (from the 1986 operation) that need to be drained, rinsed and disposed of. These barrels do not have the volume of residue that the ones at St. Louis had, but all contained at least some malathion that has not been disposed of since 1986.

The pesticide-handling procedures used at Dakar airport with the big planes (C130 and DC7's) were generally exemplary during the period 15-23 November. Proper clothing and safety equipment were being used. Malathion from new barrels was being used and the workers did a good job of draining the barrels, leaving a minimum of residue. An outstanding job was done in containing and cleaning up the 400 gallon pesticide spill at the Dakar airport that occurred on 18 November.

Pesticide barrel disposal may be a problem, especially with the volume of pesticide being used with the big planes. (The three big planes can use over 150 barrels/day). Old barrels in poor condition that cannot be recycled for pesticide use should be drained, rinsed, crushed and buried. The drained pesticide and diluent should be consolidated in properly labeled barrels and then used in the spray program. Barrels that can be reconditioned for pesticide use should be sold only to a reputable company with explicit instructions on their cleaning, reconditioning and reuse. There is high potential for pesticide barrel misuse since empty barrels are coveted for water and food storage.

Issues that need to be addressed with regard to rinsing old barrels are the amount of diluent to be added to the used barrels and the number of rinses that are necessary. EPA guidelines, which have been recommended for use in Africa (Overholt 1984), state that a standard (200 liter) barrel should be rinsed three times, each rinse using 20 liters of diluent. This practice would result in 60 liters of contaminated diluent (30% of original barrel contents) for every empty barrel, creating a major disposal problem in itself. This is especially true for oil-based pesticides such as malathion that must use diesel fuel as a diluent.

Another recommendation for barrel disposal in Africa, is that the tops of barrels be cut off to facilitate complete draining (Anonymous 1988). This is also probably not practical in most situations. A more practical and realistic procedure for Africa would be to do what I described above: rinse used barrels one time with 1-2 liters of diluent after draining the pesticide residue for 30 seconds.

2. <u>Pesticide handling, Senegelese Crop Protection Service program</u>

The Senegelese Crop Protection Service has an active program of providing villagers with pesticide (usually 3% fenitrothion powder) for use in backpack sprayers and cloth bag "dusters" to control locusts. Knittle (1988) noted cases of improper handling of these pesticides by villagers. I observed the same types of problems: excessive application rates, handling and application of pesticides without protective clothing, and application of pesticide upwind of people so that the powder drifted into the people. There was at least one case of two cats and perhaps chickens dying in a village after fenitrothion powder was applied excessively (Carly Wand, U.S. Peace Corp volunteer, personal comm., 20 November 1988 and Appendix 2). Knittle (1988) has made recommendations to the Crop Protection Service for rectifying this problem. I concur with his recommendations.

3. <u>Pesticide application, U.S. program</u>

I observed the C130 aircraft applying fenitrothion on two dates and malathion on five dates from 15 to 22 November. Pesticide application was at the calibrated rate of about 0.5 to 0.6 liter (A.I)/ha. The spray pattern, swath width (300 m), droplet size and delivery elevation (35-50 m) all appeared appropriate.

Spraying was conducted between sunrise (0700) and 1100 when ground temperature ranged from 18 to 32°C and wind velocity from 0 to 19 km/hr (usually below 12 km/hr). The C130 stopped spraying when ground winds exceeded 19 km/hr. I estimated locust kill at over 90% in areas covered by spray (Tables 1 & 2). The big problem was navigation and coverage of the treatment area. On each pass in a spray block, the C130 had difficulty in locating the boundary of the previously sprayed swath. This often resulted in unsprayed areas or double sprayed areas of the treatment block. The Senegalese CPS could assist by providing distinct boundary markers (e.g., colored smoke) for the spray block each day. The big planes definitely needed ground support, with radio communication, to help guide them in the treatment blocks.

Other problems with the 1988 spray program were that the spray program began 2-4 weeks later than it should have and there was too long of a delay between entomolgical surveys defining a treatment area and the actual spray. Most of the agricultural damage (hoppers feeding on millet, sorghum, peanuts and cassava) had already occurred in October and early November and many of the bands of hoppers had molted into adults and were flying by the time of the sprays. Although the spray areas I monitored still had plenty of locusts in them at the time of spraying, the numbers appeared to be considerably less than what I had observed a week before the sprays. I noted numerous cassava, peanut and millet fields that had been stripped of vegetation by the hoppers.

Villagers did a good job of covering wells during spray applications. Eight of nine wells I observed in spray areas had been covered. Villagers reported no adverse effects to livestock after U.S. spray applications. Villagers appeared pleased with the spray program; their main complaint was that it should have been timed a few weeks earlier.

4. Short-term effects on wildlife, U.S. program

I did pre- and postapplication surveys of birds in two treatment areas, one sprayed with fenitrothion and the other with malathion. There was no significant ($P>0.20$, T-test) difference in the total number of birds observed pre- and posttreatment (Tables 1, 2). I also walked approximately 10 km in these areas during both pre- and posttreatment periods. I noted three dead birds during the pretreatment period and two during the posttreatment period. All appeared to be road kills from vehicles. I saw no evidence of pesticide-affected birds or other wildlife and none was brought to my attention by villagers.

A nesting colony of buffalo weavers (*Bubalornis albirostris*) feeding newly fledged adult locusts to their nestlings was monitored before and after spraying (Table 3). The colony appeared to be thriving one day after direct spraying with malathion. The birds continued to feed locusts to their young, but changed their behavior by flying about 1 km from the nesting site to an area where living locusts were found in bundles of harvested millet stalks lying on the ground. The birds did not feed on readily available, dead locusts around the colony where they had been feeding immediately before the spray.

Table 4 lists the bird species observed feeding on locusts. I am certain that many other bird species were feeding on this abundant food source, but were simply not observed during my trip.

Summary of Important Issues

1. All contractors should handle pesticides properly for their own health and to set good examples for the host country. Everyone recognizes that it takes additional time and effort to put on proper clothing and use proper equipment when handling pesticides, especially in hot climates. However, if pesticides are going to be used, especially in large quantities over a protracted period of time, it is necessary to follow accepted handling procedures.

2. A standardized policy on barrel draining, rinsing and disposal needs to be developed. The following summarizes my recommendations for a practical policy.

   a). Barrels should be thoroughly drained at the time of use. This involves tipping the barrels up and allowing to drain for 30 sec.

   b). If barrels are in good shape and can be reconditioned, the contract with the company purchasing the barrels should specify that they will be used only for pesticides that are compatible with the reconditioned lining of the barrel.

   c). Barrels that can not be reconditioned should be rinsed with 1-2 liters of diluent and drained for 30 sec. The consolidated rinse should be used in the spray program. The barrels should then be crushed and buried. The U.S. EPA triple rinse protocol should not be followed in Africa.

3. The big planes need better navigation and ground marking aides to assist them in providing uniform coverage over treatment blocks.

4. Although the environmental assessments that were performed did not indicate any adverse effects of the spray on wildlife or livestock, it is emphasized that the posttreatment assessments done were short-term (1-2 days after spray) and somewhat superficial. Time and manpower constraints simply did not allow for longer term and more extensive environmental assessments. The basic procedures used appeared to work satisfactorily. Major improvements I suggest are:

   a). Pretreatment assessments in an area to be sprayed should be run on at least two dates within the week before treatment. Posttreatment assessments should be run on at least three dates (1-2, 3-4, and 5-6 days after treatment).

   b). A more detailed breakdown of bird species should be used in future assessments with special emphasis on the species noted to feed on locusts (Table 4).

c). More time should be spent observing nesting colonies of birds in the treatment area pre- and postspray.

5. Although not a part of my assignment, I noted that there did not appear to be a standard procedure for evaluating the level of locust kill after a spray in a treatment block. I would suggest the following:

a). A minimum of 20 sample sites should be examined from throughout the treatment block one day after spray. At each site, an observer should walk a transect approximately 100 m long and count or estimate the number of living and dead locusts within a 1-m wide band. The use of a hand-held counter would be helpful. This would provide an objective measure of percent kill over the treatment area.

6. Toxicity data on the various insecticides being used or proposed for use in locust control indicate that fenitrothion is the most likely to adversely impact the environment (Table 5). Malathion or carbaryl should be used whenever possible. I also question statements made regarding fenitrothion in the Programmatic Environmental Assessment Report for Locust and Grasshopper Control in Africa (Anonymous 1988). This report states that fenitrothion "is less toxic to fish than many of the other insecticides" and that it "be used, with caution toward birds, only near aquatic environments where fisheries might be threatened" (Page F-8). The toxicity data I reviewed (Table 5) indicate fenitrothion is highly toxic to aquatic organisms. Thus, I would disagree with these statements.

__Acknowledgements__: I thank the personnel of the U.S. AID office in Senegal for their support and many courtesies extended during my stay. I am especially appreciative of the assistance of Director Sarah Jane Littlefield, Dave Robinson, Jim Bonner and Mawa Diop. A special thanks goes to Khui Nguyen Le who enthusiastically assisted me on most of the environmental assessments and helped me find my way around Senegal. I also acknowledge the support and assistance from the hard working locust team members I was associated with: Paul Joseph, Charlie McDonald, Alan Mudge, Gordon Orloff, Flip Phillips, and Rudy Tantare. These people put in incredibly long days and nights to get the spray program off the ground and running. Final notes of appreciation go to Ed Knittle and Rick Bruggers who did an excellent job laying the groundwork for my trip to Senegal.

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Knittle, C. E., 1988. Interim report: environmental assessment locust control program - Senegal. 6 pp.

Overholt, W. 1984. Pesticide user's guide: a guide for extension workers in West Africa. Reg. Food Crop Prot. Proj. No. 625-0928. 107 pp.

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Table 1. Pre- and posttreatment observations of nontarget organisms on 28 km survey route from Pir Goureye to Mekhe, Senegal. This survey route was within a 10 x 60 km area sprayed with fenitrothion from a C130 aircraft at the rate of 0.5 liter/ha on 15 and 16 November 1988.

	Pretreatment (13 Nov. 1988)	Posttreatment (17 Nov. 1988)
No. of survey stops	16	14
Birds/stop[a]		
No. of doves	0.43	0.57
No. of shorebirds	0.13	0.38
No. of hornbills	0.38	0.21
Birds of prey	0.06	0.79
Swallows and swifts	0.44	0.00
All other birds	11.31	8.43
TOTAL BIRDS	12.76	10.38
Insects/stop[b]		
Butterflies	0.69	0.50
Predatory Dipteran[c]	0.31	0.36
Other	1.56	2.43
Locusts	164.81	13.86

[a] Number of birds observed within 100 m of road during 2 km interval between stops plus number of birds observed within 500 m of road during 30 sec interval at stop.

[b] Number of insects observed within circle of 5-m radius at side of road.

[c] Tentatively identified as Callostoma fascipennis, order Diptera, a predatory insect that captured and fed upon grasshoppers.

Table 2. Pre- and posttreatment observations of nontarget organisms on 45-km survey route from Mekhe to Touba Toul, Senegal. This route was within a 20 x 20 km area sprayed with malathion from a C130 aircraft at the rate of 0.6 liter/ha on 17-18 November 1988.

	Pretreatment (13 Nov. 1988)	Posttreatment (17 Nov. 1988)
No. of survey stops	10	12
No. of birds/stop[a]		
Doves	6.00	4.50
Shorebirds	0	0.08
Hornbills	0.30	0.17
Birds of prey	1.10	2.00
Swallows and swifts	0.60	0.67
All other birds	79.20	46.00
TOTAL BIRDS	87.2	53.42
No. of insects/stop[b]		
Butterflies	0.50	0.29
Predatory Dipteran[c]	0.60	0.21
Other	1.40	0.64
Locusts	147.0	7.14

[a] Number of birds observed within 100 m of road during 2 km interval between stops plus number of birds observed within 500 m of road during 30 sec interval at stop.

[b] Number of insects observed within circle of 5-m radius at side of road.

[c] Tentatively identified as Callostoma fascipennis, order Diptera, a predatory insect that captured and fed upon grasshoppers.

Table 3. Observations of a nesting colony of buffalo weavers immediately before and 24 hrs after being sprayed with malathion at rate of 0.6 litér/ha, Senegal 1988.

	Prespray (21 Nov. 1988)	Postspray (22 Nov. 1988)
No. of nests in tree	10	10
No. of adult birds observed	18	18
Feeding rate/min*	2.5	3.0

* Average number of locusts brought to tree/minute by adult birds during a 10 minute observation period.

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Table 4. Birds observed to feed on locusts, 8 - 22 November 1988, Senegal.

Bird Species	Comments
Long tailed glossy starling (*Lamprotornis caudatus*)	Observed several birds feeding on locusts
Blue-eared glossy starling (*Lamprotornis chalybaeus*)	Observed three birds feeding on 5th instar nymphs
Yellow wagtail (*Motacilla flava*)	Observed one bird feeding on 5th instar nymphs
Buffalo Weaver (*Bubalornis albirostris*)	Adults were feeding nestlings the newly emerged adult locusts
Yellow-billed oxpecker (*Buphagus africanus*)	Observed one bird feeding on locusts
Red-beaked hornbill (*Tockus nasutus*)	Commonly seen feeding on locusts
Black kite (*Milvus migrans*)	Captured adult locusts in flight

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Table 5. Estimated LD_{50} values (mg/kg) of chemicals proposed for use in locust control, Senegal, 1988*.

Organism	Chemical			
	Malathion	Carbaryl	Chloropyrifos	Fenitrothion
Daphnia	1.0	6.4		0.01
Catfish	8,970	15,800	280	4.8
Lake Trout	76	690	98	2.2
Carp	6,590	5,230		12
Quail		>2,000	68.3	27
Rat	1,000	500-850	3,800	800

* Data from Handbook of Toxicity of Pesticides to Wildlife, U.S. Fish and Wildlife Service Resource Publication No. 153 (1984) and Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates, USFWS, Resource Publication No. 137 (1980).

APPENDIX I

ITINERARY FOR RICHARD A. DOLBEER
SENEGAL LOCUST CONTROL PROGRAM
3 - 24 November 1988

DATE	LOCATION	ACTIVITY
3-4 Nov. 1988	Cleveland to Washington, DC	Briefings, travel arrangements
5 Nov.	Dakar, Senegal via New York City	Travel
6 Nov.	Dakar	Rest and orientation
7 Nov.	Dakar to St. Louis	Planning for survey and spray operations
8-9 Nov.	St. Louis to Richard Toll and return	Locust and bird survey
10 Nov.	St. Louis	Pesticide handling and barrel disposal
11 Nov.	St. Louis to Dakar	Pesticide handling and barrel disposal, travel
12 Nov.	Dakar to Fatick and Bombey and return	Locust and bird survey
13 Nov.	Dakar to Mekhe and return	Pretreatment bird survey
14 Nov.	Dakar to Kebemer and return	Pretreatment bird survey
15-19 Nov.	Dakar to Mekhe and return	Spray monitoring for C130 and environmental assessment of treated areas
20 Nov.	Dakar	Pesticide handling at Dakar Airport
21-22 Nov.	Dakar to Mekhe	Spray monitoring for C130 and environmental assessment
23-24 Nov.	Dakar to Cleveland via New York City	Debriefing at AID office, Dakar, travel

APPENDIX II. Letter from U.S. Embassy medical doctor to Peace Corp Volunteers regarding pesticide use in Senegal.

To: Peace corp volunteers
(Senegal, Gambia, Cape Verde, and Mauritania)
From: Chad Meyer, M.D.
Subject: Pesticide use in West Africa

As regional medical officer at the embassy in Dakar, I share responsibilities for coverage of PCV's medical care in the absence of the Peace Corps Medical Officer. Dr. Sedgric Dumont will be returning to Senegal during the first week of December.

As everyone has become aware West Africa has been besieged with locusts. In the past week I have seen several PCV's in the clinic and listened to stories about both the effects of locusts, and pesticides used in attempting to control them. It became readily clear that those of you who have been, or will be in areas where pesticides are used, have concerns for your own safety and that of the people with whom you live and work. I have attempted to obtain as much information as possible on this topic, and I will try to present this to you in a pragmatic format.

Commonly used pesticides are usually categorized into the following three groups:

1) organophosphate cholinesterase-inhibitors:
malathion (Cythion), fenitrothion (Agrothion),

2) carbamate cholinesterase-inhibitors:
propoxur (Baygon),

3) solid organocholine compounds.
dieldrin (Dieldrite), benzene hexachloride (BHC, HCH)

The enzyme acetylcholinesterase is essential to normal transmission of nerve impulses along nerve fibers. When a critical mass of this enzyme is inactivated by cholinesterase-inhibiting insecticides, poisoning occurs. Although the mechanism is different, organocholine insecticides also interfere with normal functions of the nervous system. All three classes of insecticides act by causing depression of respiration (failure to breath) when toxic amounts are absorbed. For cholinesterase-inhibitor toxicity (poisoning) to occur a large enough dose of the insecticide must be absorbed to cause a deficiency of acetylcholinesterase. Because pesticides are metabolized (broken down) by the liver, for poisoning to occur either very large amounts of the pesticide must be absorbed during a short period of time, or smaller amounts must gradually deplete acetylcholinesterase over a longer exposure interval.

The international response to the locust infestation has involved a number of donors (USA, and various European countries) providing pesticides, equipment, and "expertise." Because of the extent of this years infestation, and the diversity of responding countries, there has been some disagreement in regard to the best insecticides to use. The USA has in general a more conservative attitude toward which agents may be used. In addition, USA supplied aircraft are only permitted to spray with insecticides approved for use in the USA. Since aerial spraying

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is being performed predominantly by American planes, there is a selection biass in favor of shorter acting and less environmentally harmful insecticides.

Aerial spraying is being performed with malathion. This is a "organophosphate cholinesterase-inhibiting" pesticide. The characteristic of malathion which makes it relatively safer, is its short period of potency. Within several hours following its application malathion breaks down into inactive byproducts. As a result, there is no "residual" built up which could be harmful to the persons or animals inhabiting an area where malathion is used. However, because of its short duration of effect malathion must be applied directly onto locusts. Since there is no residual effect with malathion, it is ineffective to apply malathion in an attempt to "protect" an area against locust invasions days or weeks away. The logistics of malathion use mandate that reconasaince must be performed daily; each evening a team of entomologists and pilots select areas to be sprayed on the next day. The advantages of malathion are secondary to its rapid break-down:

1) unharvested crops are not contaminated,
2) residuals are not left to contaminate soils,
3) cumulative levels do not occur which could harm livestock or people residing in areas sprayed.

All organophosphate insecticides (malathion included) are absorbed by inhalation, ingestion, and through skin penetration. Malathion is primarily a potential hazard for individuals exposed to it on a chronic basis: personnel loading malathion onto aircraft and directly involved in spraying. Because of its low toxicity for humans, even having malathion sprayed onto the skin (as a single exposure) would not represent a serious risk. Needless to say, anyone so exposed would be advise to wash the area with water to remove the insecticide from the skin, thereby limiting the amount absorbed. Additional measures which limit the amount of pesticide absorbed include the following:

1) wearing a broad-brimed hat which can shield the head from aerosol insecticide,
2) carrying a hankerchief for placing over the mouth and nose (limits inhalation exposures),
3) carrying an extra set of clothing when traveling away from your home village; if inadvertantly caught under an aerial spray, changing clothes will limit contact with the pesticide and decrease the amount absorbed,
4) attempt to avoid repeated exposures,
5) since fields sprayed with malathion are considered safe after the insecticide has dried (become inactive), it is best not to re-enter treated fields for 24 hours.

Such guidelines are obviously useful for the villagers with whom you have contact. Discussions with them concerning these guidelines, particularly remaining away from a sprayed field until the malathion has dried, could have obvious benefits.

A second cholinesterase-inhibiting pesticide, fenitrothion, comes in a powder and is being employed in ground-spaying activities. Fenitrothion is active for about three days before breaking down into a non-active form. From reports I have received from some volunteers, it appears that fenitrothion is also being distributed to villagers who sprinkle the substance around houses and fields. Entomologists tell me that a heavy application of fenitrothion is no more effective that a very light sprinkling of the substance. If persons have prolonged skin or inhalation contact with fenitrothion it can be harmful. In my discussions with some volunteers I have heard reports of cats dying after exposures in villages. Again, the entomologist tell me that cats are especially vulnerable tc this substance. I would be particularly concerned about small chilren having prolonged exposure to the powder. Insecticides are only poorly appreciated by peoples from developed countries, and the potential for their harm is even less appreciated by persons in the developing world who have had little contact with their use. I would suggest that you may be of particular benefit to your village, or neighboring villages by warning (or reinforcing) the dangers of insecticides, and particularly their danger for children.

I have also been informed that European donors have provided the following substances which have been baned in the USA:

benzene hexachloride (BHC, HCH)

dieldrin. [7].

Both of these substances belong to a group referred to as organocholine pesticides, and there use has been limited to ground applications.

Based on my continuing discussions with volunteers and with members of the AID community involved in the pesticide program I would summarize by saying that the aerial spraying program does not pose a potentially hazardous problem for individuals living in areas being sprayed, including individuals who even may directly receive a small dose of malathion spray from the air. The insecticide powder fenitrothion which is being used by department of the agriculture protection service has a residual of three days, and should not be harmful when employed as intended: as a powder blown from trucks. However, villagers who may be given the powder for hand application may use it in fashions making it harmful; most dangerous would be heavy applications, and prolonged and repeated exposure of the substance to the skin. Children and small animals would be particularly vulnerable.

Since it is anticipated that "the locust problem" will be present in future years, insecticide use will become a more common occurrence in West Africa. As volunteers you are in a unique position to both observe what occurs at the village level, and to assist in educating about both the dangers and proper use of insecticides. Photographs and journals which you keep could be very useful in providing information that could change existing practices. If you observe what you think are dangerous uses of insecticides, or if you observe illnesses which appear to be insecticide poisoning, I would urge you to report it to either myself, or Dr Dumont. We will also attempt to answer any questions which you may have as a result of this note, or of what you have seen from the field.

BCM 11/88.

TRIP REPORT*

SENEGAL and MAURITANIA

January 29-February 21, 1989

G. Keith LaVoie

International Programs Research Section

Denver Wildlife Research Center

Science and Technology

Animal and Plant Health Inspection Service

U.S. Department of Agriculture

Denver, Colorado 80225-0266

Unpublished Report

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ABSTRACT

Rodent surveys were conducted in four regions of the Senegal River Valley: Matam, Kaedi, Richard Toll, and Saint Louis. Sampling provided data on the dominant agricultural rodent pest species, their relative densities in relation to crop type, and quantitative rodent damage assessments in available crop types. The dominant pest rodent was Arvicanthis niloticus. Rodent densities were highest in fallow rice fields, or rice fields with secondary crops, and in vegetable producing areas. Rodent densities were highest in Matam, followed by Saint Louis, Kaedi, and Richard Toll, respectively. Damage assessments indicate severe rodent damage to vegetable seeds and seedlings; however, damage assessment data are very limited because only a few crops were being grown at this time of the year. These preliminary data strongly suggest that cost/benefits are very favorable to Senegal and Mauritania for the development and implementation of effective national rodent control programs.

OBJECTIVES

The objectives of this trip were to assess rodent problems to agricultural areas in the Senegal River Valley in Senegal and Mauritania when "normal" rodent densities could be expected: specifically, (1) to identify pest rodent species as they related to crop types and geographical distribution, (2) to estimate relative rodent densities by crop type and geographical distribution. and (3) to make quantitative rodent damage assessments to growing crops when identifiable rodent damage was encountered.

BACKGROUND

Severe chronic rodent problems and spectacular periodic rodent irruptions have probably occurred in Sahelian Africa for centuries (Fall, 1976; Poulet, 1985). Following a period of drought, Senegal had ample rain in 1985 and 1986. Severe rodent damage to crops in Matam was reported in October 1986, and very high rodent densities in 1986 and 1987 prompted the Minister of Rural Development to request additional funding for rodenticides and related materials in February 1987. In response to this sitation (similar situations were occurring across Sahelian Africa), AID/Washington provided funds to the Denver Wildlife Research Center for an assessment and recommendations. In May 1987, I assessed the severity of the rodent problems and made recommendations in Senegal (LaVoie and Elias, 1987a) and three other countries (LaVoie, 1987; LaVoie and Elias, 1987b,c). A site visit in the Senegal River Valley confirmed extremely high densities of Arvicanthis niloticus and Mastomys spp. The cowpea-peanut-millet agricultural area from Louga to beyond Linguare was also reportedly heavily infested with Taterillus pygargus at this time. Approximately 366,000 ha were heavily infested with rodents.

The potential for severe rodent damage to crops during the 1987 growing season was evident. However, the Senegal River Valley irruption peaked prior to the 1987 planting season. The subsequent rapid decline in rodent

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densities to "normal" levels (LaVoie, 1988) probably resulted from diseases and famine in the rodent populations. The rapid decline of rodents from irruption densities to chronic densities is the usual terminus to this phenomenon; however, the application of timely control methods can result in significant economic and health benefits. Chronic infestation densities are not as spectacular as irruption levels; however, crop damage is still usually significant. Poulet (1985) speculates that chronic densities of A. niloticus build and peak or irrupt about every 4 years in Senegal.

CURRENT SITUATION

Recommendations following my 1987 consultancy to Senegal include the immediate need to prepare for future irruptions and to relieve the high rodent damage to crops from the chronic rodent densities. Consequently, research is needed in each affected agricultural situation in the Sahelian zone to determine rodent pest species, assess chronic rodent densities and current rodent problems, to develop rodent control methodology, and to train Senegalese and develop an effective vertebrate pest control program in Senegal. This consultancy initiated research to begin meeting some of these needs. This research was carried out in four areas along the course of the Senegal River. They were Matam, Richard Toll, and Saint Louis in Senegal and Kaedi in Mauritania (Fig. 1). These areas were chosen on the advice of Dr. Khoi Nguyen Le, USAID/Senegal agronomist. Each area has a history of rodent damage to crops, and collectively these areas span the major portion of the Senegal River Valley bordering Senegal and Mauritania. Figures 2, 3, and 4 show general vegetation zones and climatic zones of Senegal.

MATERIALS AND METHODS

Samples and specimens were drawn from growing crops, fallow fields, and adjacent noncrop borders in each of the four geographical areas. The sampled crops and fields were recessional sorghum, corn, fallow rice fields, and vegetable producing areas. Sampling sites were selected based on the recommendations of local personnel involved in crop protection or agriculturalists and by personal searches. Rodent damage to crops was reported at these sites within the preceding 6-month period. Table 1 shows sites by location and primary and secondary crops.

Rodent sampling for species identification was made by setting kill traps (McGill rat size snap traps) at points where evidence of rodent activities was found. The number of traps at any given point was arbitrary, based on the amount of rodent signs and available traps. Traps were set and baited with peanut butter or potato in the late afternoon and picked up early the following morning. Rodents were identified, weighed, sex determined, reproductive condition observed, and these data recorded.

Table 1. Description of crops and fields at each sampling area and site in the Senegal River Valley.

Area	Site	Description (primary crop/secondary crops)
Matam	1	Fallow rice fields/corn and some onions growing
	2	Fallow rice and sorghum fields/beans; some cabbage, peppers, and onions growing
	3	Fallow sorghum fields/corn, onions, and cassava growing
	4	Sorghum/intercropped beans
	5	Vegetables
	6	Vegetables
	7	Vegetables
Kaedi	1	Vegetables
	2	Vegetables
	3	Vegetables
	4	Vegetables
	5	Vegetables
	6	Fallow rice fields
	7	Sorghum
	8	Corn
	9	Vegetables
	10	Fruit trees
	11	Vegetables
Richard Toll	1	Fallow rice (rain fed)
	2	Fallow rice (irrigated)
Saint Louis	* 1	Vegetables
	6	Vegetables
	7	Fallow rice fields (irrigated)
	8	Pasture

* Sites 1-5 were small adjacent sites and were grouped as Site No. 1.

Relative rodent densities were estimated by counting burrow openings along randomly selected 100-m transects. Openings were counted in an area about 3 m wide on each side of the transects. The only stipulation for a starting point and direction of a transect was that it follow the available rodent harborage. In this manner, over 60 transects were selected and burrow openings counted in the four geographical areas.

Quantitative damage assessments were made in sorghum and corn fields by examining 100-m transects selected at random, estimating the total plants per transect and counting the number of rodent damaged plants on the transect. Vegetable assessments were made by determining the number of plants per bed or field and counting the plants damaged or destroyed by rodents. Because of the perishable nature of vegetables, rapid replacement of damaged plants, and the rodents' selectivity for young vegetable plants, only damage caused within a 2- to 3-day period prior to the assessment could be identified as rodent damage. Farmers often gave testimonials of rodent damage which had occurred previously; however, this was not verifiable or quantifiable.

RESULTS

Species identification

The dominant rodent pest species trapped was *A. niloticus* (91%) in the four geographical areas sampled. A total of 21 *A. niloticus*, 1 *T. pygargus*, and 1 *Mastomys erythroleucus* were trapped during 97 trap nights. Overall trap success was 30.0%, including 3 shrews (*Crocidura* sp.) and 3 hedgehogs (*Erinaceus* sp.). However, about 70% of all traps were active; this value includes not only traps that captured animals but also those that were sprung. Agriculturalists in Kaedi and Matam also reported serious crop damages from the ground squirrel (*Xerus erythropus*). Details of the trapping activities are presented in Tables 2 and 3.

Relative rodent densities

A total of 62 transects were counted for rodent burrow openings in the four sample areas. These consisted of 12 in Matam, 29 in Kaedi, 8 in Richard Toll, and 13 in Saint Louis. The rodent density index (burrow openings/transect) was highest in Matam (33.5), followed by Saint Louis (22.3), Kaedi (20.6), and Richard Toll (7.9), respectively. Rice fields, both fallow and with secondary crops, in all locations showed the greatest amount of rodent activity, while vegetable producing areas were second. Recessional sorghum and corn field transects showed only nominal rodent activity. Details and summaries for the rodent density transects are given in Tables 4 and 5. It should be noted that at chronic densities *A. niloticus* live in social units occupying one burrow system usually with about 3 to 6 openings. A social unit appears to consist of 10 to 15 adult animals at this time of year. It also seems that all the members of each social unit forage within a defined territory.

Table 2. Rodents trapped at four areas in the Senegal River Valley.

Area	Site	Species	Sex	Weight (g)	Pregnant
Matam	1	A. niloticus	M	148	
		A. niloticus	F	150	No
		A. niloticus	F	131	No
		T. pygargus	F	42	No
	2	A. niloticus	M	170	
	3	None	-	-	-
	4	None	-	-	-
	5	A. niloticus	M	144	
		A. niloticus	F	120	No
		A. niloticus	F	85	No
Kaedi	1	None	-	-	-
	2	A. niloticus	M	96	
		A. niloticus	F	139	No
	6	A. niloticus	M	153	
		A. niloticus	M	138	
		A. niloticus	F	65	No
		A. niloticus	F	87	No
		A. niloticus	F	72	No
		A. niloticus	F	98	No
		A. niloticus	F	70	No
		A. niloticus	F	90	No
		M. erythroleucus	M	30	
Richard Toll	1	None	-	-	-
	2	A. niloticus	F	110	No
Saint Louis	1				
	6	A. niloticus	M	155	
		A. niloticus	F	119	No
		A. niloticus	F	120	No

Table 3. Trap success by primary crop and area.

Crop	Area	No. sites	Rodents trapped	Trap nights	Trap success (%)
Rice	Matam	2	5	29	28*
	Kaedi	1	9	19	63**
	Richard Toll	2	1	13	08
Total		5	15	61	$\bar{x}$ 25
Vegetables	Matam	2	3	16	19
	Kaedi	2	2	17	12
	Saint Louis	2	3	13	23
Total		6	8	46	$\bar{x}$ 17
Sorghum	Matam	1	0	10	0

* Includes 3 *Crocidura* sp.
** Includes 3 *Erinaceus* sp.

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Table 4. Relative density of rodents in four areas in the Senegal River Valley.

Area/ site	Burrow openings/ transect	Area/ site	Burrow openings/ transect
Matam		Richard Toll	
2	27	1	11
	52		8
	37		10
3	50		3
	42		4
	30	2	9
4	0		12
	0		6
	9		
5	62	Saint Louis	
	75	1	9
7	18	6	12
			8
Kaedi			27
1	110	7	48
	55		12
	42		19
2	20		9
	26	8	48
5	0		28
	0		38
	0		26
6	22		6
	40		
	0		
	0		
	0		
	8		
	40		
	56		
	32		
	48		
	16		
	35		
7	0		
	0		
	0		
	0		
	0		
	0		
	0		
9	42		
11	04		

Table 5. Mean burrow openings by primary crop and area.

Crop	Area	No. sites	Transects	$\bar{x}$ Burrow Openings (S.D.)
Rice	Matam	2	6	39.7 (10.75)
	Kaedi	1	12	24.5 (20.10)
	Richard Toll	2	8	7.8 (3.27)
	Saint Louis	1	5	29.2 (15.66)
Vegetables	Matam	2	3	51.7 (29.87)
	Kaedi	5	10	29.9 (34.65)
	Saint Louis	2	4	14.0 (8.83)
Sorghum	Matam	1	3	3.0 (5.12)
	Kaedi	1	7	0.0
Pasture	Saint Louis	1	4	22.0 (17.83)

Crop damage assessments

Recessional sorghum and corn in Matam and Kaedi showed no rodent depredation at this time (all fields examined were near harvest). However, farmers were adamant in their claims that rodents destroyed many seeds and seedlings soon after planting and germination.

To have reliable damage assessments of vegetables would require daily inspections during the seedling stages and weekly inspection until harvest, since replacement of seeds or seedlings is a common practice. Values, based primarily on damage occurring 1-2 days prior to my assessments, are shown in Table 6. Cabbage and onions ("cool-weather crops") were particularly vulnerable to rodent damage at this time.

Table 6. Crop damage assessments in four areas in the Senegal River Valley.

Area	Site	Crop	Damaged/undamaged	% Damaged
Matam	1	Corn	0/50	0
		Onions	3/200	1.5
	4	Beans	10/100	10.0
Kaedi	2	Vegetables	13/100	13.0
	3	Vegetables	0	0
	4	Vegetables	0	0
	5	Vegetables	0	0
	6	Vegetables	150/512	29
	7	Sorghum	0/600	0
	8	Corn	0/150	0
	10	Fruit trees	0	0
	11	Vegetables	0	0
Richard Toll	3	Vegetables	0	0
Saint Louis	1	Vegetables		
		Cabbage	66/600	11
		Potatoes	312/338	94
	6	Vegetables		
		Cabbage	435/978	45
		Onions	966/2240	43
	7	Vegetables		
		Potatoes	75/800	9
		Tomatoes	*	>20

* Gross visual estimate.

DISCUSSION

A. *niloticus* is considered by Meester and Setzer (1971) to be a monotypic species in the genus. These diurnal rodents have a wide distribution, ranging from Egypt to Zambia and from Senegal to Kenya. They are vegetarians, consuming only seeds and green plant materials. Unlike some rodents, they require free water. The data gathered during this consultancy indicate that this species is a primary pest to agriculture in the Senegal River Valley. However, longer trapping periods, resulting in the removal of A. *niloticus*, may show other species are also significant, e.g., *Mastomys* spp.

The synchroneity of increasing rodent densities with increasing abundance of food is well known. This general concept is well demonstrated in agricultural environments when rodent densities climb as crops mature and is particularly evident in climatic zones where wet and dry seasons prevail. Fertility and fecundity increase annually to meet the available resources. A rather rapid decline in densities usually follows the decline in available food, i.e., harvesting and exhaustion of reserves and alternate foods. Numerous other variable climatic factors influence the gains and declines in rodent numbers; however, this simple model is applicable to the Senegal River Valley and will surface for the purpose of this report.

A. *niloticus* probably reach peak densities between October and January each year. Minimum densities probably occur in June of each year. Thus, it is not surprising that Can (unpublished report, 1987) says that complaints of extreme rodent depredations to crops came from Matam in October 1986 and from farmers all along the valley by Feburary 1987, since those years encompassed an irruption of rodents throughout much of Sahelian Africa (LaVoie, 1987; LaVoie and Elias, 1987a,b,c; Fiedler, 1987). This irruption was mitigated in Sudan (Keith, 1987) and dissipated in several other countries prior to the 1987 planting season. Ample precipitation in 1988 (Table 7) provided the primary prerequisite for a reliable estimate of chronic rodent densities during this consultancy.

Table 7. Precipitation data for the Senegal River Valley between Bakel and Saint Louis from 1986 to 1988.

Area	1986	1987	1988	3-year average	30-year average
Bakel	452.0	420.0	662.9	511.3	470.6
Matam	334.0	470.0	421.1	408.4	410.4
Pondor	244.2	188.0	307.0	246.4	257.0
Saint Louis	156.9	339.7	310.4	269.0	266.0

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Quantitative crop damage assessments were limited by the replacement practices and the ephemeral nature of rodent damage to most vegetable crops, obscuring the total damage picture; however, damage was extremely severe when it was encountered. When farmers complained of damage or it was obvious, they were usually using chlorophacinone baits. The control techniques they employed, such as the amount of bait used, placement of bait, and distribution of baits, appeared to be generally ineffective.

The species identifications, relative rodent densities, and damage assessment information presented here should be used as a first step in a series to determine the impact of rodents to Sahelian agriculture in the Senegal River Valley. Similar studies at different times of the year and others, such as bait evaluations, will lead to the development of effective rodent control methodology and training of Ministry of Rural Development personnel in vertebrate pest management techniques. These data presented here, although preliminary, strongly indicate that the cost/benefits of development and implementation of a national rodent control program based on the principles of integrated pest management would be very favorable for Senegal and Mauritania.

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Faye, Chief, Matam
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Diarra Mamadou, Director
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Mohamid Ould Tomba, Regional Director

ORSTOM/Mibour

Jean-Marc Duplantier, Biologist

SAED/Matam

Amadou CISSC, Deputy Chief

ORSTOM/Dakar

M. Durend, Plant Physiologist

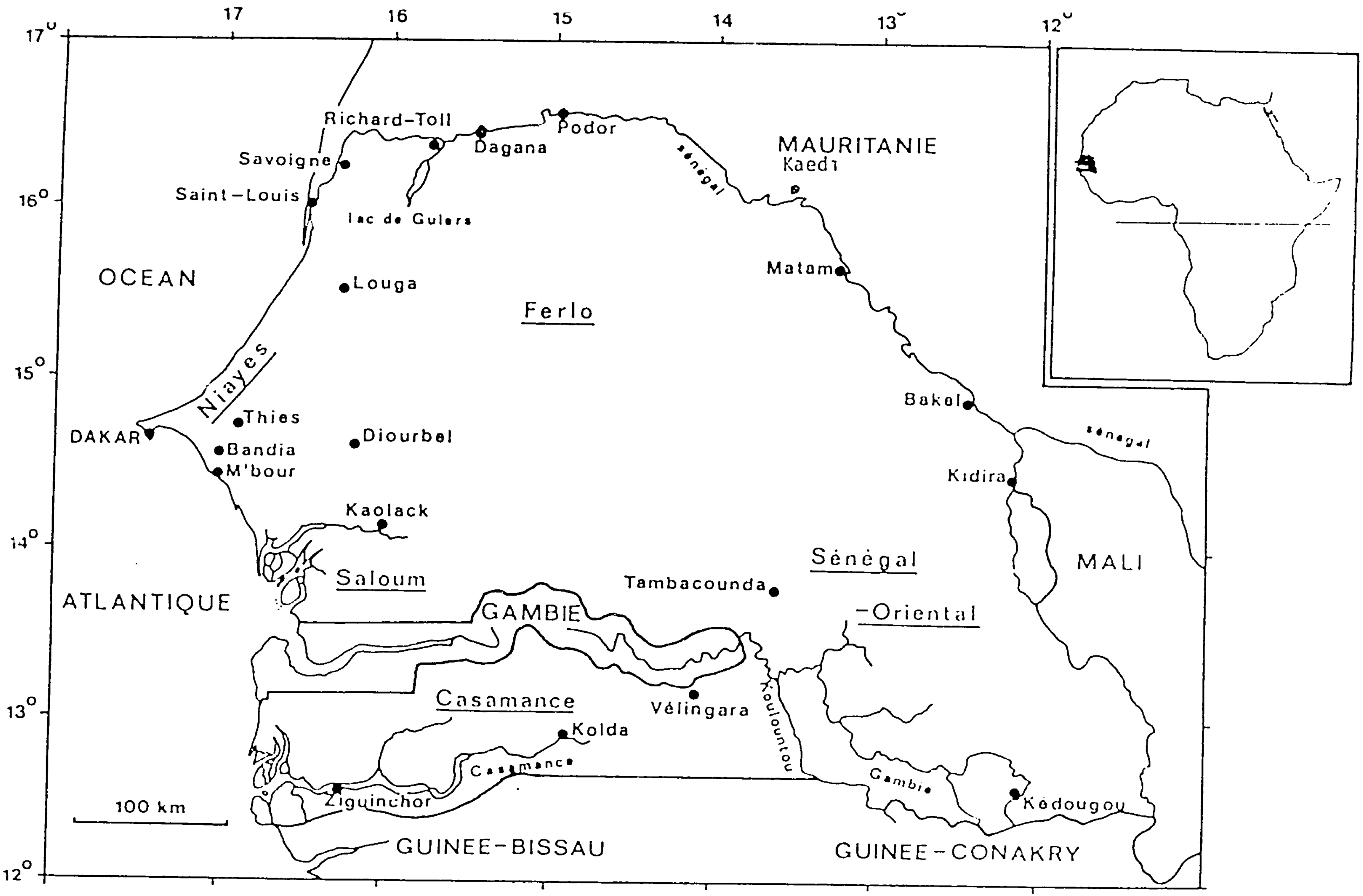

Fig. 1. Carte géographique du Sénégal (d'apre's Duplantier, 1988)

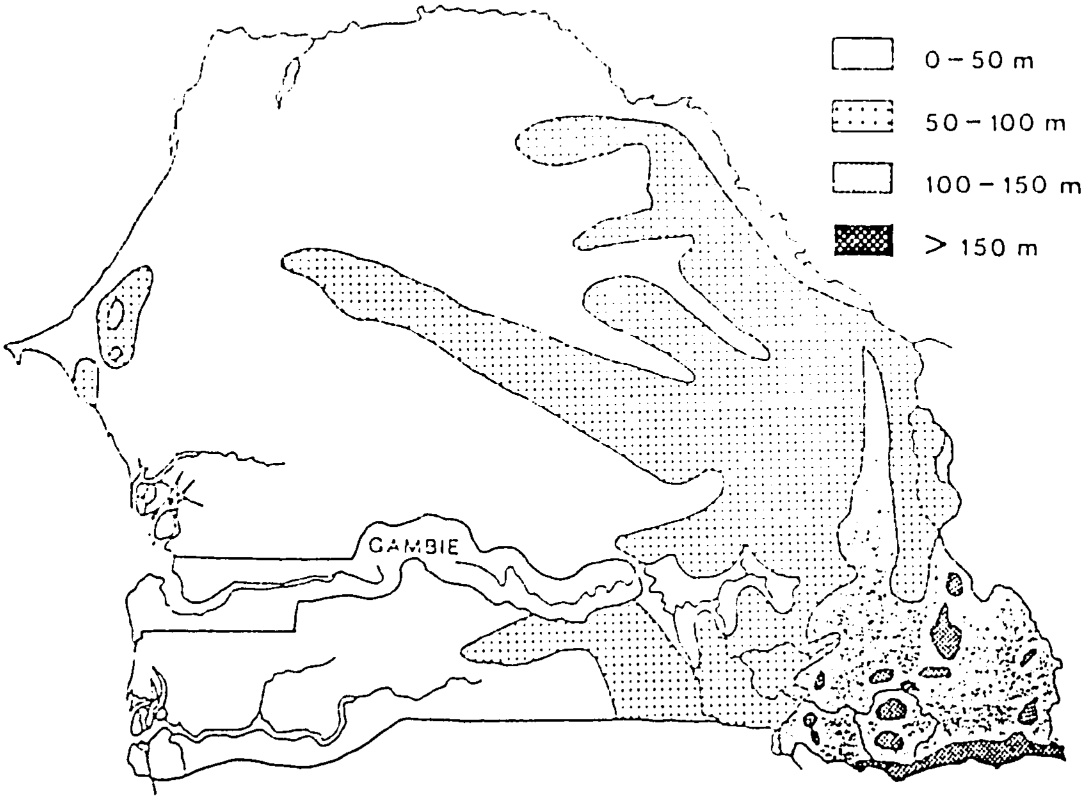

Fig. 2. Relief (d'après Michel & Sall, 1980)

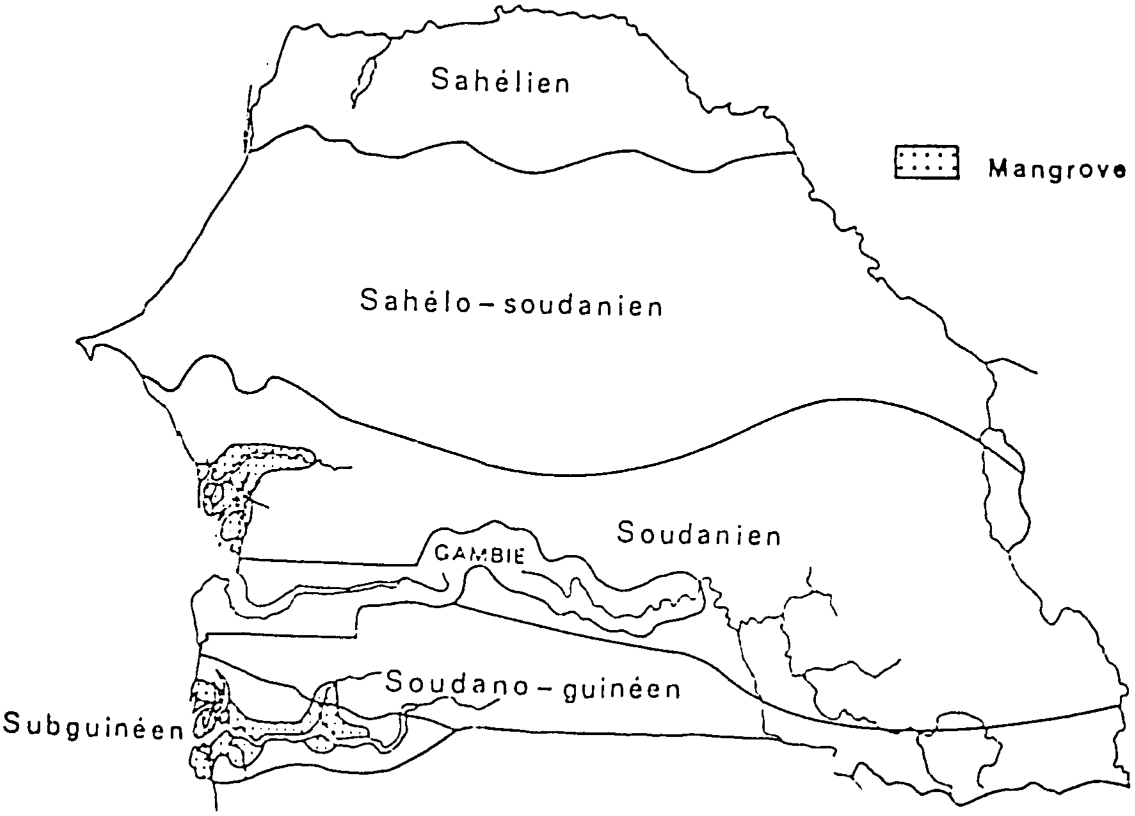

Fig. 3. Domaines phytogéographiques (d'après N'diaye,1960)

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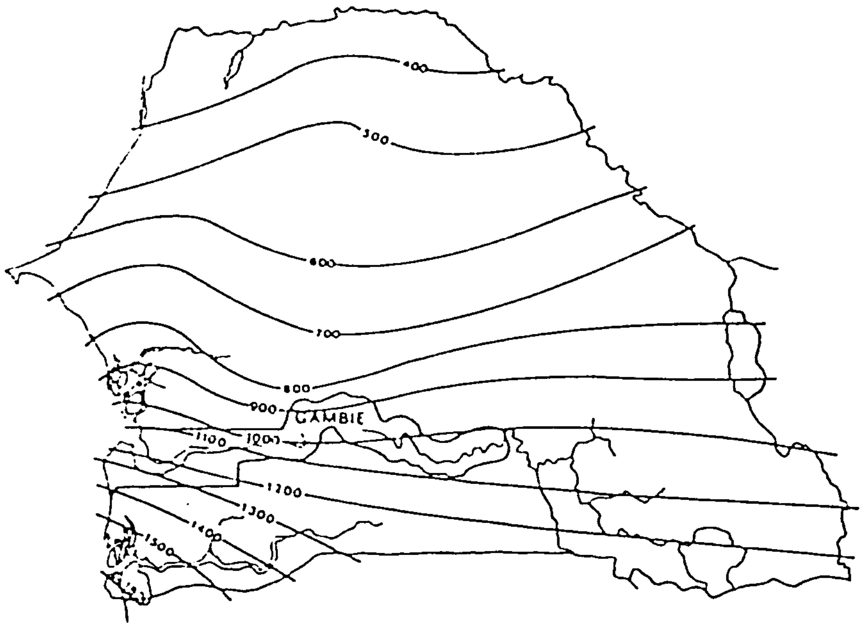

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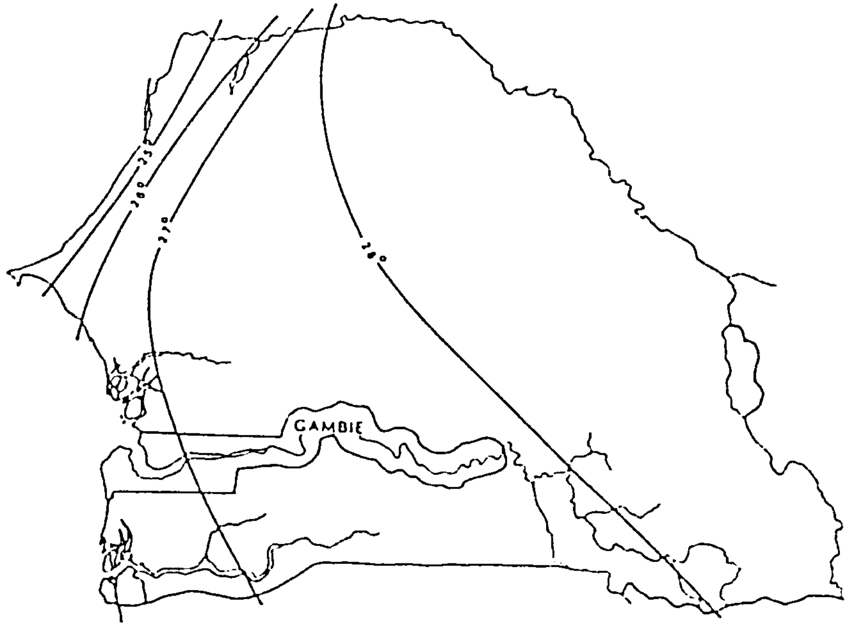

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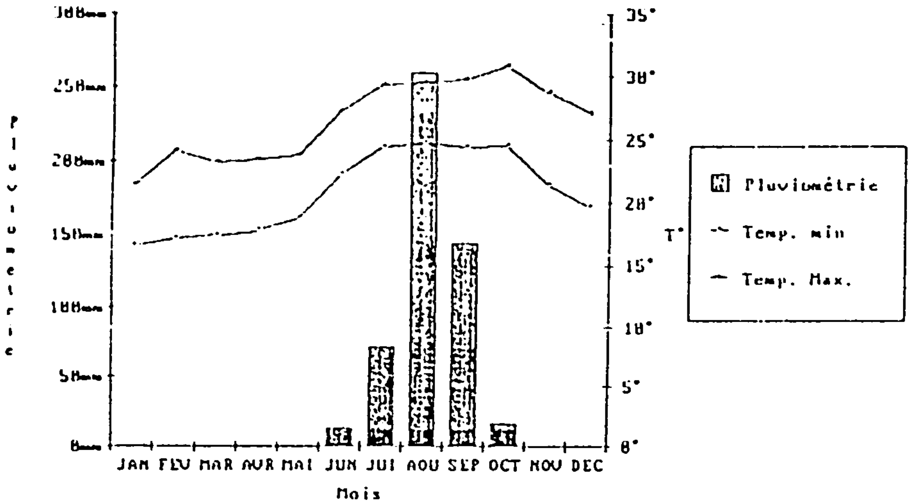

Fig. 4. Climatologie

A Isohyètes moyens annuels (d'après Leroux,1980)

B Isothermes moyens annuels (idem)

C Diagramme pluviothermique de DAKAR-YOFF en 1985

TRIP REPORT*

PROJECT PLANNING AND WILD BOAR RESEARCH

PAKISTAN

February 3-March 6, 1989

by

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ABSTRACT

A 1-month visit to Pakistan was made in February-March 1989 to assist the cooperative vertebrate pest management program on wild boar control. My involvement with the program included the trapping and netting of wild boar, the evaluation of one toxicant--an anticoagulant (coumatetralyl)--for wild boar control in wheat fields, and the collection of wild boar for biological studies. A 4-year research proposal has been drafted that recommends both biological and toxicological studies to be conducted on the wild boar.

BACKGROUND

After rats and mice, wild boar (*Sus scrofa*) are the most important vertebrate pests in Pakistan. Originally this species was restricted to riverine habitat; however, with the development of irrigation canal systems in Punjab and Sind, the wild boar have increased their range throughout the Indus plain. This has brought the wild boar in contact with food crops which they now feed upon and which now constitute a major part of their diet. Crops affected include sugarcane, sorghum, peas, melons, potatoes, corn, peanuts, wheat, and rice. The economic losses in food production caused by this animal now justify researching methods for controlling wild boar populations.

In 1985, the Denver Wildlife Research Center, Denver, Colorado began a cooperative vertebrate pest management program in Pakistan. One phase of this program emphasizes prevention of preharvest damage by wild boar. Under the direction of Joe Brooks and his staff, initial testing of control methods for reducing wild boar damage to food crops and collection of baseline data on the biology of the species have begun. This research is intended to develop various methods of crop protection mainly through population reduction of wild boar. The methods will be applied to protect the crops at those stages of plant growth when they are most vulnerable to wild boar.

A 1-month TDY visit was made in February-March 1989 to assist in this wild boar research program. The specific terms of reference for this visit were:

A. To assist the Vertebrate Pest Control Project (VPCP) staff in livetrapping wild boar and to demonstrate methods of chemical immobilization and restraint.

B. To assist the VPCP in methods of radio tracking of wild boar in dry-land and irrigated cropland habitats.

C. To evaluate several chemical toxicants in baits as possible candidate wild boar control materials.

D. To assist the VPCP in designing a 4-year research proposal on the biology and control of wild boar in Pakistan.

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The operations of the wild boar traps were observed at both the Fateh Jhang and Faisalabad areas. The recommendation for modifying the trigger mechanisms on the traps was accepted. One wild boar was trapped, but escaped by climbing out or by being released. Capturing wild boar by driving them into nets was a second capture method attempted. When netting in the Fateh Jhang area, one wild boar easily broke through the net. When netting in the Faisalabad area, six shoats escaped by going under the net. Thereafter, the net was fastened to the ground.

Radio transmitters were carried to Pakistan. However, none was placed on wild boar as no animals were netted or trapped. Two shoats were captured by dogs. Both shoats were too small to attach radio transmitters to them. Wheat dough baits containing 0.375% coumatetralyl (CAS No. 5836-29-3) were placed adjacent to two wheat fields near Fateh Jhang from February 12-27, 1989. Bait consumption peaked on Day 6, then declined daily until Day 11, peaked again on Day 13, and declined to zero on Day 15. Six wild pig carcasses were located during the treatment period, but the presence of a seventh was suspected. Two nontarget domestic dogs were also killed.

Upon returning to Denver, a 4-year research proposal was drafted that recommends both toxicological and biological studies be conducted on the wild boar. These recommendations are based on the assumption that both resources and personnel will be available to carry the research proposal to completion.

Research should be directed toward development of several different methods for controlling wild boar populations. To start, a toxicant screening program to evaluate the primary toxicity of selected chemicals will be necessary. Chemical selection should be directed toward reducing primary and secondary hazards to nontarget wildlife by searching for toxicants that are more selective to wild boar. Also, different bait types should be investigated.

To accomplish these objectives, pen facilities need to be constructed. These facilities will permit the establishment of a captive breeding herd of wild boar to supply animals for toxicological studies. The pen facilities should include individual pens for bait acceptance and mortality studies with wild boar and space for housing and testing of nontarget animals in primary and secondary poisoning studies.

A. PEN AND LABORATORY STUDIES

1. Toxicants - Several chemical substances have potential as control agents for this species; this is based on information indicating toxicity to this or related species or probable selectivity for this and related species.

   a. Acute Toxicants

      (1) Rotenone (CAS No. 83-79-4) - More than any other toxicant considered for controlling wild boar, rotenone may be specific for controlling this species. This assumption

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is based on two published reports; one discussed secondary poisoning to pigs that consumed fish poisoned with rotenone, and the other reported that rotenone is toxic to pigs.

Sufficient differences may exist in LD_{50} values between wild boar and other species such as jackals and porcupines; hence, primary poisoning hazards to jackals or porcupines that might feed on the bait could be diminished. Hazards to humans formulating and handling bait would be minimal, and because of rotenone's rapid breakdown, threats to the environment are negligible.

(2) Coal Tar Products - Manufacturers of clay pigeons warn of potential poisoning in pigs if they are allowed to consume these products.

(3) 1-α-Hydroxycholecalciferol - This is a new analog of cholecalciferol synthesized by Bell Laboratories. Initial testing on white rats has shown this compound to be considerably more toxic than cholecalciferol (Vitamin D_3); for example, the acute oral LD_{50} for white rats was: males 0.76 mg/kg, females 0.44 mg/kg. Cholecalciferol's LD_{50} in white rats is 43.6 mg/kg.

(4) Benzene Sulfonic Acid Hydrazide (DRC 4575) - This compound was received from Bayer Chemical Company and screened for rodenticidal properties at the Denver Wildlife Research Center in the early 1970's. It was well accepted in bait, proven toxic to several species of rodents, nontoxic to birds, and showed no secondary poisoning risk. Lack of resources has prevented seeking a registration with the Environmental Protection Agency for this compound. Sufficient quantities of this compound are available for testing.

(5) Bromethalin (CAS No. 63333-35-7) - This is one of the newest compounds registered with the EPA for controlling commensal rats and mice. This compound has LD_{50} values of less than 10 mg/kg for wild Norway rats and house mice, low toxicity to birds, and shows no secondary poisoning risk. The compound is well accepted in bait form. Once a lethal dose has been consumed, the animals cease feeding.

b. Chronic Toxicants

Brodifacoum (CAS No. 56073-10-0) - This may have potential for controlling wild boar without risk of primary poisoning to jackals because a large differential in toxicity may exist between the two species. For example, brodifacoum is 35 times more toxic to pigs than dogs (LD_{50} 3.5 mg/kg for dogs;

0.1 mg/kg for pigs). Even considering the differences in body weight (pigs are heavier), a margin of safety may exist.

2. Laboratory Tests - Wild Boar

   a. **Bait Acceptance and Mortality Studies** - Candidate toxicants will be formulated with a carrier and fed to wild boar. Bait acceptance and mortality will be measured. If the toxicant shows promise, then additional testing will be conducted to determine the lowest effective concentration.

   b. Bait Preference Studies - Different bait types will be formulated and tested on wild boar and nontarget wildlife. Those baits that are well accepted by wild boar and poorly by nontarget wildlife will be selected for field evaluation.

   c. Markers - Fluorescent particles, microtaggents, or dyes can be incorporated into baits. These markers would aid in determining whether target and nontarget animals which were found dead had, in fact, consumed poison baits.

3. Laboratory Tests - Nontarget Wildlife

   a. Those toxicants with potential for controlling wild boar will be further evaluated on nontarget wildlife in the laboratory. These animals will be fed the toxicant at the same concentration and on the same bait as for wild boar. Bait acceptance and mortality will be measured.

   b. Secondary poisoning studies involve feeding by nontarget animals on carcasses of toxicant-killed wild boar.

B. FIELD STUDIES

1. Bait Delivery Methods - Bait stations should be tested as an alternative to the current method of bait placement. Effective bait stations would reduce the manpower requirements associated with preparing and distributing wheat dough baits and also may reduce the risk of primary poisoning to jackals.

   Proper timing of bait application to prevent crop losses should be determined for each crop. In the area around Fateh Jhang, baiting near water sources should be evaluated during the summer when water becomes limited.

   The effectiveness of flavor or odor attractants should be investigated.

2. Efficacy Indices

   a. **Scent Post Survey** - A modification of the scent post survey lines used for estimating coyote abundance may be useful for estimating wild boar numbers pre- and posttreatment. Scent

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post sites will be constructed in areas to be treated with a toxicant and measurements will be taken before and after treatment.

b. Radiotelemetry - Absolute mortality figures, following baiting, home range information, and movement patterns are among the kinds of information obtainable with radiotelemetry.

c. Line Transect - The strip count or line transect method with dogs has been proven as an effective census method for wild pigs; results of line transect counts consistently compared with direct counts of wild hogs in the same area.

3. Field Testing of Selected Toxicants

a. Efficacy Trials - Efficacy can be evaluated by using radiotelemetry, perhaps with scent post surveys, and line transects with dogs.

b. Nontarget Hazards - Hazards to nontarget animals can be evaluated through radiotelemetry studies with representatives of several nontarget species that are found in treatment areas.

c. Reinvasion - After treatment, measurements can be made on the rate of reinvasion by wild boar.

4. Trapping

a. Snares - Snares should be placed on trails traveled by hogs, but only in areas where livestock are absent. Snares should be tested in sugarcane fields where hogs enter and exit.

b. Corral Traps - Permanent multicapture corral traps have the potential to reduce wild pig populations in mesquite groves located along canals near Faisalabad. Traps could be operated during the time period when the hogs are congregated in or near the mesquite groves; more specifically, that is after the wheat harvest and before the sugarcane is tall enough to provide cover for the pigs (May through September).

5. Dogs

a. If radiotelemetry identifies areas where sows consistently farrow, then during the peaks of the two farrow seasons, dogs would cover these areas and catch and kill the piglets.

C. PEN STUDIES - WILD BOAR BIOLOGY

Growth, development, reproduction, and nutrition data can be obtained from pen-reared wild boar. This type of information can be used to design methods for aging animals in the wild, studying the dynamics and trends of wild populations, and perhaps may lead to discovery of an exploitable factor (weak link) that will facilitate control of the population and alleviation of economic damage.

1. Growth

   a. Morphometric Measurements - These would be obtainable from birth until growth stops on both sexes of known age, penned, reared wild hogs. These measurements can be used to develop methods for estimating the age of free-ranging animals.

2. Development

   a. Pelage Changes - Changes in the pelage for both sexes could be recorded from birth until the final pelage form occurs. The ratio of the different adult color types could be calculated.

   b. Tooth Eruption - Sequence of eruption, loss of deciduous teeth, and eruption of permanent teeth could be taken from known-age animals. Measurements would begin at birth and continue until the last permanent molar has completely erupted.

   c. Eye Lens Weight - This tissue, when obtained from known-age animals taken periodically from birth to about 4 years of age would give validity to this aging technique for wild boar.

3. Reproduction

   a. Length of Estrus - Utilizing a vasectomized wild boar, the number of hours a female remains receptive to a boar could be determined.

   b. Estrus Interval - Again, utilizing a vasectomized wild boar, the number of days between estrus cycles could be determined.

   c. Breeding Seasons - Questions concerning number and length of breeding periods could be resolved.

   d. Length of Gestation - The number of days from conception to birth could be determined.

   e. Number of Young Per Litter, Sex, and Survival - With a captive herd of wild boar under laboratory conditions, these parameters could be determined.

   f. Minimal Breeding Age for Both Sexes - Although both sexes appear to be capable of breeding at an early age, the actual minimal age at which breeding initially occurs could be determined.

   g. Behavior - The courtship and mating behavior of both sexes could be described.

4. **Food Consumption**

   a. Average daily consumption for the different weight classes of pigs could be measured.

D. FIELD STUDIES - WILD BOAR BIOLOGY

Data on growth, food habits, aging, and reproduction from over 300 wild boar shot to date probably constitutes the largest data bank on this species. Data obtained to date and recommendations are as follows:

1. **Growth Maturation** - The morphometric data obtained in 1987, 1988, and 1989 by collecting free-ranging wild boar should be sufficient for all age groups 5 months of age or older. Data for age groups from birth to 4 months for both sexes is minimal; additional animals 0 to 4 months of age should be collected.

2. **Food Habits Analysis** - From the area around Faisalabad, stomach contents from over 300 wild boar are available. Collecting began in March 1987 and continued through September 1989. This large sample size should be sufficient to identify the major food items of the wild boar by season and years. Because the identification of the food habits analysis has not begun, allowing an advanced degree student access to the stomach samples might prove more expedient for completing the analysis.

   To estimate food consumption, the stomach and contents should be weighed and the stomach should be reweighed after emptying the contents. Also, the volume of each stomach should be determined.

3. **Tooth Eruption and Eye Lens Weight** - Dentition and eye lens weight are two techniques that permit aging of wild boar in Pakistan up to 26 months of age. For those animals 26 months and older, research continues on an aging method by counting annular rings of dentine and cementum of incisor teeth. The existing sample of 66 wild boar that are 24 months or older may prove adequate to validate aging this species by annular ring counts.

4. **Reproduction**

   a. **Sexual Maturity** - Sufficient testicular and ovarian development data that have been obtained from pigs collected near Faisalabad suggest that both sexes become sexually mature at about 6 months of age. These data agree with reproductive development data reported for wild boar outside of Pakistan.

   b. **Breeding and Farrowing Seasons** - Reproductive data for 1987 and 1988 suggest that both sexes of wild boar are capable of breeding throughout the year. However, the data suggest two peak seasons: a 5-month period from April to August and a 2-month period during January and February. Whether the farrow season observed to date is consistent among years can only by determined by farrowing data collected over a number of years.

Analysis of farrowing data collected in 1989 will contribute another year's data. It is recommended that data collection continue at least from October through December 1989, and beyond, if possible. Factors contributing to the initiation and cessation of the breeding seasons should be explored.

5. **Neonatal Litter Size** - From a sample of 97 pregnant females, the data suggest young females (<24 months of age, mean neonatal litter size = 4.77 individuals) have smaller litters when compared to older females (>24 months of age, mean neonatal litter size = 6.56 individuals). Additional information as to neonatal losses would be the difference between the number of corpora lutea and the number of embryos or fetuses present. The sex ratio of the embryos or fetuses can be determined.

6. **Mammaries** - From a sample size of 151 females, the mean number of teats per sow was 8.3 $\pm$ SD of 1.0. This number agrees with the mean number of teats previously published for female wild boar from Pakistan. Additional data to be obtained would include the number of functional teats of suckling sows. Because each pig will suckle only a single teat, data on litter sizes of postnatal pigs could be obtained.

7. **Movement** - Studies should be conducted on radio-equipped wild boar inhabiting areas adjacent to both dry land and irrigated farming practices. Some parameters to be measured would be:

   a. Home Range Size and Configuration - These are defined as the area included within a line connecting outermost locations.

   b. Seasonal Movement - Do seasonal movements of wild boar occur between the higher elevation and adjacent areas of dry land farming, and do movements of wild boar occur between areas adjacent to the irrigation canals and surrounding irrigated farm land?

   c. Activity Patterns - Hog movements would be tracked for 24-hour periods for the four different seasons of the year. Activities recorded would be feeding, resting, moving, and mating.

   d. Habitat Use - The vegetation within the range of the radio-equipped wild boar would be classified into the various cover types, and the frequency of the wild boar in each cover type could be determined.

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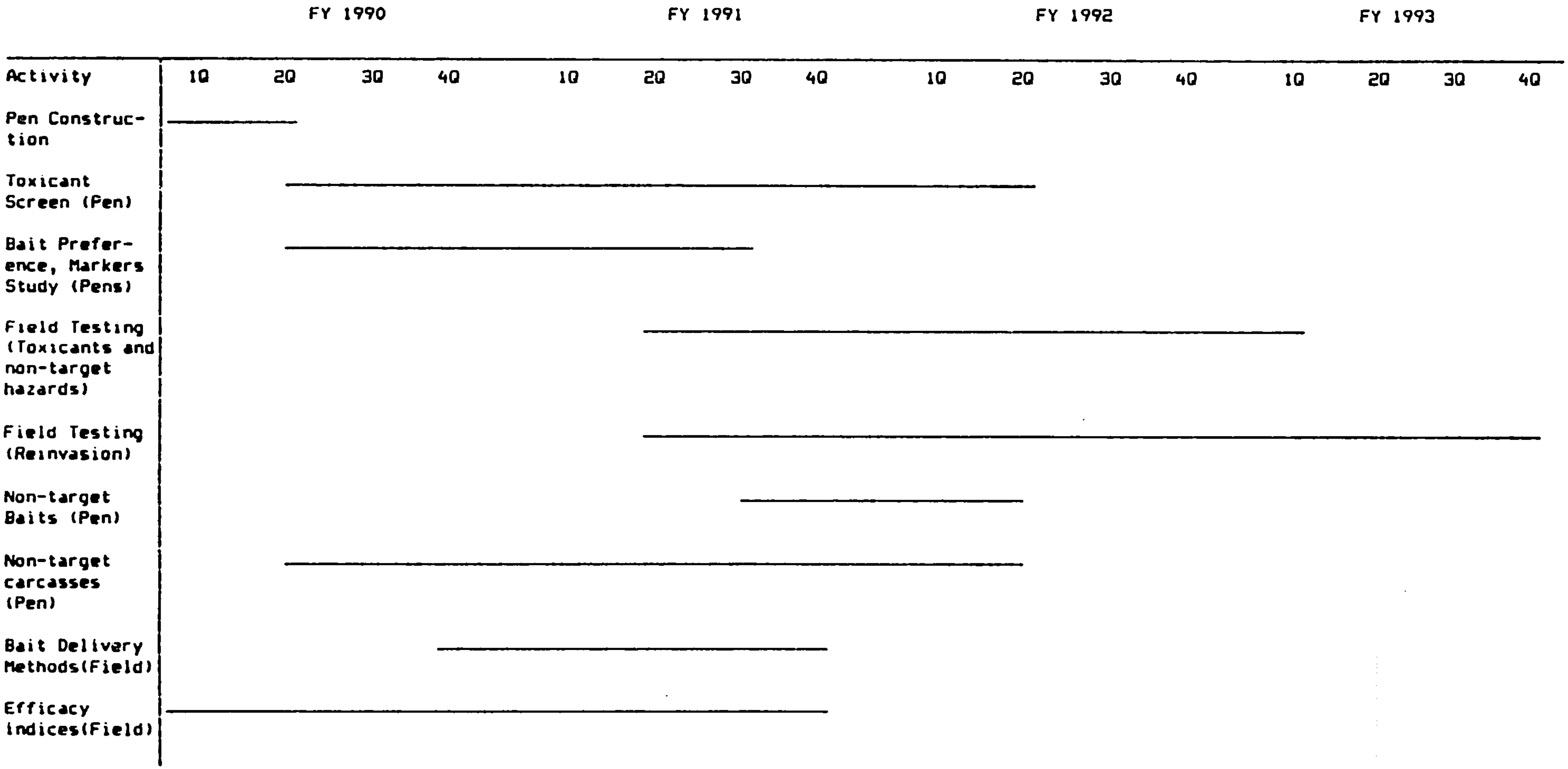
Schedule of Activities



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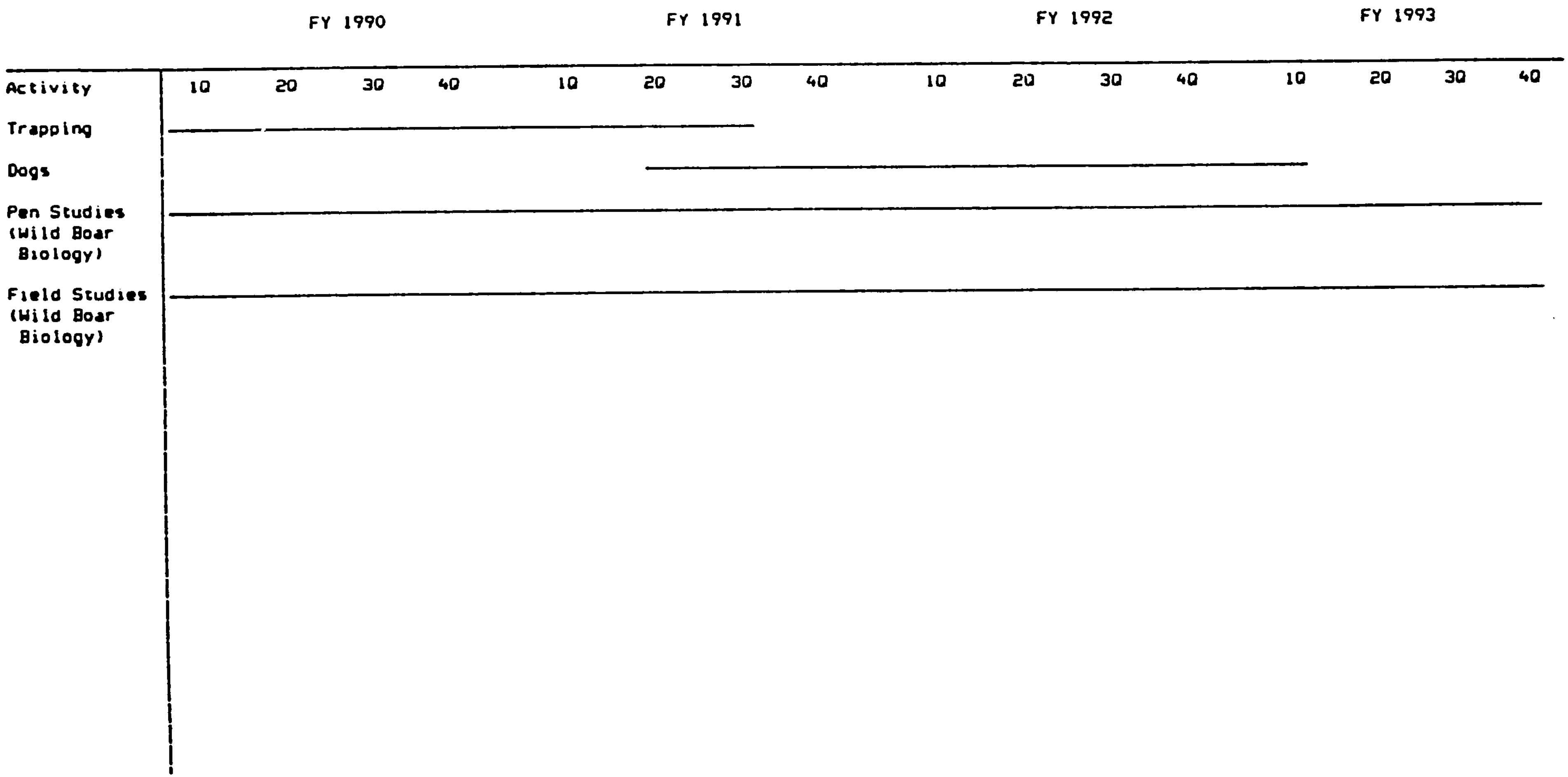
Schedule of Activities



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Islamabad

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ITINERARY

Date	Location	Activity
February 3-5	Denver, Colorado to Islamabad, Pakistan	Travel
February 5	Islamabad	Met with USAID/ARD and NARC/VPCP staff.
February 6	Islamabad and vicinity	Met with USAID/ARD staff; wild boar study area near Fateh Jhang area.
February 7	Islamabad	Radiotelemetry equipment testing; activities and plans discussed; literature reviewed.
February 8	Islamabad and vicinity	Vertebrate Pest Control Training Workshop at Daultala.
February 9-13	Islamabad to Barani Livestock Development area and return	Toxicological testing of candidate poisons for control of wild boar; radiotelemetry studies on wild boar.
February 14-16	Islamabad	Vertebrate Pest Control Project
February 17	Islamabad to Faisalabad	Travel
February 18	Faisalabad and vicinity (Jaranwala)	Contacted the farmers of villages 56, 65, and 66 regarding hog damage to wheat and sugarcane. Tried netting wild pigs. No pigs were shot.
February 19	Faisalabad and vicinity (Shehhupuna)	Visited the farm of Ch. Umar Draz. Tried netting wild pigs. Six (4 male, 2 female) were shot and data collected.

Date	Location	Activity
February 20	Faisalabad and vicinity	Visited village 393/J.B. No netting of wild pigs was tried. One (female) was shot and data were collected.
February 21	Faisalabad and vicinity (Cheragh Abad village)	Cheragh Abad village and villages 295/J.B. and 296/J.B. Tried netting wild pigs. No pigs were shot. One trap was set at the Punjab Agricultural Research Station of the University of Agriculture.
February 22	Faisalabad	One trap was set at the Air Force Base at Faisalabad. Two animals were killed during the night and data were collected. One (female) weighing 11 kg was captured and placed in the trap at the Punjab Agricultural Research Station.
February 23	Faisalabad to Islamabad	Checked the dental pattern of the small female; processed the reproductive tissue of the wild pigs that had been shot. Returned to Islamabad.
February 24	Islamabad and vicinity	Visited the wild boar study area near Fateh Jhang. Obtained data on bait consumption, and visited the carcasses of four wild pigs killed by coumatetralyl treatment.

Date	Location	Activity
February 25	Islamabad and vicinity	Returned to the wild boar study area near Fateh Jhang. Obtained data on bait consumption and selected site for confining the trapped wild pigs.
February 26	Islamabad	Sick
February 27	Islamabad	Trip report
February 28	Islamabad and vicinity	Trip report, and visited the study area near Fateh Jhang. Transferred the two pigs from Faisalabad into the holding pen.
March 1	Islamabad	Trip report, discussion, and overview of 4 years of proposed research on wild boar with Thomas Olson of the NARC/VPCP staff.
March 2	Islamabad	Trip report
March 3	Islamabad	Day off
March 4	Islamabad	Trip report, and visited the study area near Fateh Jhang. Body and weight measurements were recorded for the two wild boars.
March 5-6	Islamabad, Pakistan to Denver, Colorado	Travel

Trip Report

Locust/Grasshopper Management Workshop
USAID
Dakar, Senegal
February 6-10, 1989

and

Planning Meeting
Studies of Locust
Insecticide Effects on the
Environment
Rome, Italy
February 14-16, 1989

by
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International Programs Research Section
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February 27, 1989

This project was conducted with funds contributed to USDA/APHIS, Denver Wildlife Research Center by the Office of Foreign Disaster Assistance, USAID.

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Itinerary

February 3	Travel to New York.
February 4-5	Travel to Dakar, Senegal.
February 6-10	Participated in USAID locust meeting.
February 11	Travel to Rome, Italy.
February 12	Sunday.
February 13	Discussions with FAO specialists on locust control.
February 14-16	Participated in planning for international cooperation on studies to determine environmental effects of locust control.
February 17	Travel to Denver, Colorado.

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In Dakar I attended the USAID Locust/Grasshopper Management Workshop as a resource person on the environmental effects of pesticides. At the meeting, locust control activities during 1988 (Attachment 1) and plans for control in 1989 were reported by locust project officers from USAID Missions in Chad, Ethiopia, Jordan, Mali, Mauritania, Morocco, Niger, Senegal, Sudan and Tunisia. In addition, 24 specific issues of concern were discussed. these ranged from cost-benefit analysis, survey techniques, communications, operations planning and management, to environmental concerns. Members of the USAID Desert Locust Taskforce and Office of Foreign Disaster Assistance along with specialists on remote sensing, communications, locust biology and control, efficacy of pesticides, aerial application of pesticides and environmental effects of pesticides were present at the meeting (Attachment 2).

I presented a brief statement on the kinds of wildlife effects that could occur from use of organophosphate insecticides against locust (Attachment 3). Members of the group showed an interest and concern about environmental effects and several asked for research proposals that their missions could consider. There was general agreement that comprehensive studies of effects on non-target organisms, environmental contamination, and human and livestock exposure should be conducted. A report of this meeting should be available in March, 1989.

While at the meeting in Dakar, I received a request to participate in a meeting sponsored by FAO in Rome. The objective of this meeting was to plan studies proposed by the Netherlands, Great Britain and FAO on the environmental impact of insecticides used for locust control. A pilot study is being considered for 1989 along the lower Senegal River to identify the kinds of effects that result from applications of locust insecticides. Following this study a decision will be made on the need for a longer term study (3 years) to more fully investigate the impact of the pesticides.

On February 13, I worked at FAO headquarters on an outline of wildlife studies that should be considered. The planning session was held February 14-16; attendees are listed in Attachment 4. During the first day we discussed possible studies on effects of fenitrothion, chlorpyrifos, bendiocarb, diflubenzuron and lamda cyhalothrin on birds, mammals, fishes, and aquatic and terrestrial invertebrates in savanna, wetland and agricultural habitats. It quickly became evident that the scope of work had to be narrowed and that meaningful bird studies would require more manpower than the one Dutch ornithologist available for the work. At this point James Everts suggested that USAID/DWRC join in the proposed research to provide more thorough evaluation of effects on birds.

On February 15, discussions continued with consideration of study habitats, plot size, numbers of plots, and chemicals to be evaluated in studies of different organisms. In the afternoon, participants separated to prepare work plans for studies in their area of expertise. Plans considered objectives, general approaches in studies, specific experimental methods, data analysis, schedules, personnel requirements and equipment needs. Fenitrothion and chlorpyrifos were selected for studies with birds, while for other organisms those two insecticides and diflubenzuron, an insect growth regulator, will be evaluated. Five, 12 km^2 plots will be established in savanna habitats for bird and terrestrial invertebrate studies. One plot will be a control area and 2 levels (1X and 2X the recommended levels) of the two insecticides will be applied to the other 4 plots. Two additional 10 km^2 plots will be treated with diflubenzuron for fish and invertebrate studies.

On the morning of February 26, work plans were reviewed and refined by the group. Later in the day I revised the bird study plan and prepared a detailed listing of equipment needs including make, model, source of items and cost. A report on the meeting with complete study plans will be available in March.

Dr. James Evert will be study director. In June, 1989, he will be in Senegal to obtain authorizations and permits, select general study areas along the Senegal River, arrange for rental vehicles, set up camps (2), process shipments through customs, and establish relations with Senegalese agencies and counterparts. Team members will arrive in late June to select sites for study plots. Pretreatment data will be obtained in July and posttreatment data in August after spraying. It was agreed that a report of 1989 activities and findings would be prepared by November 1.

The Denver Wildlife Research Center has often been asked to assist USAID in the review and evaluation of their programs dealing with pesticide use and vertebrate pest management. Too often, however, the Center has not been involved in the planning phases and has not been able to help develop objectives and methodology. It was particularly gratifying to attend the meetings reported here! In both cases the Center had the opportunity to contribute information and perspective before plans for 1989 were formulated. The center has the practical expertise in ecology to provide for environmental assessment of pesticide effects and management of vertebrate pests; we are pleased to use these talents when they are needed and at the time when they are the most effective.

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Attachment 1

CONTROL OPERATIONS IN 1988
(hectares treated)

	I - VII (Jan - July)	VII-XII (July - Dec)	
Algeria	2,016,000	140,000	2,156,000
Morocco	2,600,000	1,750,000	4,350,000
Tunisia	360,000		360,000
Libya	86,000	33,000	119,000
	5,062,000	1,923,000	6,985,000
Mauritania			847,000
Mali			520,000
Cape Verde			20,000
Senegal			2,500,000
Gambia			125,000
Niger			960,000
Chad			105,000
			5,077,000
Sudan			1,150,000
Ethiopia			45,000
Djibouti			5,000
			1,200,000
Saudi Arabia			1,200,000
Yemen AR			6,000
Yemen PDR			
United Arab Emirates			
Qatar			
Kuwait			
Iraq			5,000
Iran			5,000
Jordan			3,000
Syria			
Lebanon			
Turkey			
			1,219,000
			14,481,000

Attachment 2

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DAKAR, SENEGAL
FEBRUARY 6-9, 1989

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Attachment 3

SOME POSSIBLE EFFECTS OF ORGANOPHOSPHATE AND CARBAMATE INSECTICIDES ON BIRDS

1. Practically all investigations of these insecticides have uncovered some undesirable effects. Important effects are those of greatest intensity and persistence, especially when they influence long-term productivity and population maintenance in birds.

2. Effects can be direct or indirect.

   a. Direct effects are related to the toxicity of the insecticides. These include mortality, but also physiological impairments that restrict normal functions such as behavior or reproduction.

   b. Indirect effects are those related to habitat changes that reduce life requirements, such as amounts of food, or the increased energy demands required to search for alternate foods.

3. Some locust insecticides can cause direct effects, such as mortality, but as they all are broad spectrum insecticides; most also reduce food supplies and energy available for breeding, moult, migration, and other essential functions.

4. Effects can be subtle. DDT was widely used for years before the mechanism of egg shell thinning was identified as the process responsible for population declines in predaceous birds. It is possible that some organophosphates and carbamates can:

   a. Reduce longevity through impairment of vital functions (demyelination of nerve bundles).

   b. Influence behavior, such as the escape response to predators.

   c. Impair physiological functions. Nasal salt glands, which are used by birds to conserve water, can be inhibited by organophosphates.

   d. Reduce reproductive success.

   e. Create energy stress in migratory birds. Some organophosphates restrict appetite and cause anorexia.

5. Cholinesterase is an enzyme that deactivates acetylcholine and thereby limits the length of time nerve impulses are transmitted. Cholinesterase inhibition can burn out the nervous systems of animals and cause death. Cholinesterase is inhibited by organophosphate and carbamate insecticides, and the degree of inhibition indicates the severity of exposure. Therefore, cholinesterase measurements are a diagnostic tool to determine the intensity of exposure of birds and the cause of mortality in ones found dead or moribund.

6. Organophosphate and carbamate insecticides are not generally as persistent as chlorinated hydrocarbon insecticides (DDT, dieldrin), but they can persist for prolonged periods in certain environmental materials (documented in holly leaves and fish). Additional sampling is needed to adequately define where residues may persist. Weekly water samples from the middle of the Tule Lake National Wildlife Refuge (35,000 acres) in California all contained residues of one to five organophosphates during summer months.

7. Warm-blooded animals do not accumulate residues of organophosphates and carbamates in their bodies. They have enzymes capable of rapidly metabolizing the chemicals and often residues cannot be found in tissues of birds killed by the insecticides. Conversely, fishes, frogs, and perhaps other cold-blooded vertebrates are more resistant to the pesticides, can accumulate residues, and thus provide serious exposure to their predators. Insects debilitated and killed by the insecticides often contain enough residues to cause mortality in insectivorous animals (birds, shrews).

Attachment 4

WORKING GROUP ON ENVIRONMENTAL SIDE-EFFECTS OF DESERT LOCUST CONTROL

FAO, ROME, 14-16 FEBRUARY 1989

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DRAFT

SUBJECT TO FAO REVIEW

TRIP REPORT*

PREVENTION OF FOOD LOSSES THROUGH RODENT CONTROL

TCP/RLA/6653 (T)

A report on the fourth of four missions for improving rodent pest management in the eastern Caribbean (evaluation of the rodent control demonstration programmes and the development of a 5-year plan)

February 8-March 2, 1989

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Unpublished Report

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SUMMARY OF RECOMMENDATIONS

1. All equipment and supplies that were ordered during the course of this project except two small cement mixers have been received by each participating country. The Food and Agriculture Organization (FAO) Office should assist Grenada and St. Kitts in locating the whereabouts of the small cement mixers which were not yet delivered.

2. An adequate supply of rodenticide should be made available to those countries that have successfully completed the objectives of the FAO Rodent Control Project TCP/RLA/6653 (T).

3. FAO should provide support by sponsoring one participant from each participating country to attend a Caribbean Rodent Control Conference, which is being proposed for 1990 and hosted by the World Health Organization (WHO)/Pan American Health Organization (PAHO).

4. Extension pamphlets with recommendations for rodent control in specific agricultural crops in the Caribbean need to be developed and made available to extension agents and crop protection officers.

5. The support that FAO has recently given to rodent control in the Caribbean has been significant. Since the 1960's, the only other effort to strengthen rodent pest management on the islands was a U.S. Agency for International Development (USAID)/Caribbean Development Bank (CDB) project which funded short-term assistance on Montserrat between 1985 and 1987. FAO should continue to give support to those Caribbean countries that have demonstrated interest, ability, and the capacity to implement effective rodent control programs, but which are lacking the funds to utilize the knowledge that they now possess.

INTRODUCTION

Terms of Reference

Pilot rodent control demonstration projects were initiated in August 1988 in the countries of Barbados, Grenada, St. Vincent/Grenadines, St. Lucia, Dominica, Antigua/Barbuda and St. Kitts/Nevis. This trip report describes the evaluations of these programs. Based on these evaluations, a plan recommending rodent control efforts over the next 5 years in each of the countries was prepared.

Dates of Consultancy

This mission began February 8 and terminated March 2, 1989. Briefing sessions were held at the FAO office in Barbados on February 10, prior to individual country visits, and again on March 1 after the visits.

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Background of the Mission

On August 18, 1986, FAO entered into an agreement with seven eastern Caribbean countries to implement a rodent control project. FAO then collaborated with the U.S. Department of Agriculture (USDA) to provide a rodent consultant, Mr. Lynwood Fiedler, to carry out three missions (later extended to four). The project was initiated in May 1987 when the consultant visited and assessed the main agricultural and health-related rodent problems in each country. Agencies, organizations, and personnel involved were identified; counterparts and nominees for training were suggested. In that same mission, the consultant met with the host country officials in Grenada and planned for a rodent control training course. A consultant report detailing these activities and including recommended supplies and materials was submitted to FAO in July 1987.

Two rodenticides were selected by FAO for use in the training and demonstration projects planned for the second and third phases. Both Klerat® [1] (0.005% brodifacoum) wax blocks and Racumin® (0.5% coumatetralyl) concentrate were locally used and available in the Caribbean. The training course and demonstration projects included provisions for the safe and effective use of these and other rodenticides.

The second phase was completed in November 1987, when a 7-day rodent control training course was conducted by the consultant in Grenada. Twenty FAO-sponsored participants representing participating government agencies of Crop Protection, Extension, and Public Health attended. Training consisted of lectures, based on a Caribbean rodent control manual that was developed, slides, overheads, demonstrations, and fieldwork at or near the Mirabeau Farm Training School near Grenville. Pilot rodent control demonstration projects for each country were drafted by trainees and presented to the group for comment. A second report detailing these training activities was submitted in December 1987.

A third consultancy was conducted in August 1988, prior to the initiation of the proposed demonstration projects. A third report describing these proposed projects was submitted to FAO in September 1988. The current mission described in this report was the fourth and final one and includes an evaluation of the demonstration projects and a proposal for a 5-year rodent control plan for each country.

Acknowledgments

I thank all the persons consulted and listed in Appendix II. Special thanks goes to those individuals who took the lead role in implementing the fieldwork--Roland Harford (Grenada), Philmore Isaacs (St. Vincent), Ernest Henry (St. Lucia), Michael Thomas (Dominica), Ainsworth Grant (Antigua), Thomas Jackson (St. Kitts), and Robert Arthur (Barbados).

[1] Reference to trade names does not imply endorsement by the U.S. Government.

MAIN FINDINGS AND CONCLUSIONS

Equipment and Supplies

The list of equipment and supplies prepared and sent to each country by FAO was reviewed and discussed. Those countries which had not yet acknowledged receipt of any equipment and supplies already received were encouraged to do so immediately. According to the list provided by the FAO/Barbados Office, all equipment and supplies were accounted for with the exception of two cement mixers, one each for Grenada and St. Kitts/Nevis. One box of 100 disposable rubber gloves and two dissecting kits were delivered by the consultant to the lead agency of each country during this mission.

Rodent Control Demonstrations and Evaluation

Four of the seven countries had completed a sufficient amount of fieldwork with recorded data from which conclusions could be made. Fieldwork included snap-trapping to determine species present, the use of tracking tiles placed in fields to measure rat activity, conducting crop damage assessments, and recording the amount of bait used and the harvest or yield in baited as well as unbaited fields. Favorable results were achieved from both the agricultural and urban-related projects within the Ministries of Agriculture and Health of Grenada, St. Vincent/Grenadines, Dominica, and St. Kitts/Nevis.

Grenada

Cacao

Two 1-acre sites near the Mirabeau Farm Training Center, approximately 200 yards apart and each containing 200 cacao trees, were selected. One was baited with Klerat, 20-gram wax blocks. One wax block was nailed to 10% of the trees in the site, 1 meter above ground. Baited trees were evenly distributed throughout the site. About 20 wax blocks were added every 2 weeks from September 1988 to February 1989. Large millipedes consumed a large portion (perhaps 50%) of this bait.

Pre- and posttreatment rat activity was determined in both sites using tracking tiles. From September 1988 through January 1989, rat activity, using 50 tracking tiles, declined from 28% to about 2% in the baited plot and from 27% to about 8% in the unbaited plot. No rat damage occurred in the baited plot (42 trees with 912 mature pods), while 7.3% of sampled trees (n = 41) and 1.1% of all pods (n = 920) on sampled trees were damaged in the unbaited plot. Historically, 20-50% of pods have been damaged by rats in some cacao plantations on Grenada. Only roof rats (*Rattus rattus*) were snap-trapped (10 animals in 598 trap-nights) within these cacao plantations prior to baiting.

Sweet Potato

Two plots, 600 ft^2 and 1,000 ft^2, about 0.25 mile apart at Mardigras were selected in September 1988 for study. Heavy rains and muddy roads in October and November prevented completion of the study. However, based on trapping data (12 animals in 143 trap-nights) collected during November, Norway rats (*Rattus norvegicus*) and house mice (*Mus musculus*) were present. Likewise, about 200 grams of Klerat (10 wax blocks) were added every 2 weeks from November 7, 1988, to January 23, 1989, on the 600-ft^2 baited field. Four bamboo bait holders were used, with a wire strung through the wax blocks to hold them in place. On January 4, all uneaten blocks were exchanged (35 total) due to mold, which was probably caused by heavy rain. Rodent activity, using 24-27 tracking tiles during 2 nights (October 31 and November 1, 1988), was 8-9% in each plot. On January 10 and 11, 1989, both plots averaged about 7%.

Two plots of about 4,500 ft^2 each were selected in September 1988 near Mirabeau: one, a baited plot, at the farm school; and another, an unbaited plot, at the agricultural research station about 0.5 mile away. Harvest was 20.8% less (480 lbs *vs* 600 lbs) in the unbaited plot, which was harvested about 1 month early, in December, due to "high" rat damage. Although no damage assessments were made in previous years, rodent damage at the farm school was considered to be much less during this trial; because of this experience, sweet potatoes will be grown again in 1989. Both Norway rats and house mice (14 animals in 98 trap-nights at the farm school and 15 animals in 100 trap-nights at the research station) were trapped in each plot just prior to baiting in September 1988.

Twenty-seven tracking tiles set for 2 nights in each plot prior to baiting showed 25% activity at the farm school and 15% at the research station. Two months after baiting started, activity was 11% and 13%, respectively. Four bamboo tubes with six Klerat wax blocks wired inside were set near the corner of the treated plot. About 480 grams (24 wax blocks) were added every 2 weeks.

Livestock

The Mirabeau Farm Training Center has poultry (1,475 ft^2), rabbitry (950 ft^2), and domestic pig (3,375 ft^2) production pens that have had significant rodent damage. Egg destruction, predation of young rabbits, and feed losses in the piggery were considered chronic problems. Snap-trapping was done in September 1988, with about 70% rat- and 30% mouse-size traps at each of the three sites. Norway rats and house mice (9 animals in 99 trap-nights at the rabbitry; 4 animals in 76 trap-nights at poultry pens) were present. All three commensal rodents were present at the piggery (12 animals in 137 trap-nights). Rat activity, measured with 20-47 tracking tiles over 2 nights, was about 80% at each of the three production pens prior to baiting in September 1988. Rodenticide use (Klerat wax blocks wired to the inside of bamboo tubes) peaked (600-1,200 grams every 2 weeks) in November and December 1988. Rodent activity declined to 15-30% by January. Egg losses and predation of young rabbits declined to zero by early February when no visible active rodent burrows or runways were detected near any of the livestock pens. Animal feed had been transferred just prior to this study to a room which was more rodent-resistant. The combination of baiting and proper storage prevented any feed loss from occurring during this study.

Port Area Warehouses

Four warehouses in the St. George's port area were baited with 0.5% coumatetralyl mixed with cracked corn, to give a 0.025% formulation, and placed in bamboo tubes. Weekly bait use (0.1-0.2 kilogram at four stations per building) remained high from October through December 1988, before declining in January 1989. Rat activity, measured with 13-32 tiles, depending on the size of the building (1,000 to 9,000 ft^2), declined from higher levels (10-55%) prior to baiting in October to much lower levels in January (2-15%). In February 1989, no rat signs were visible, but some mice were reported by warehouse workers who had not seen any rats for several weeks. Also, no rodent-damaged goods were found in any of the warehouses in February.

St. Vincent/Grenadines

Sweet Potato/Peanut

Twelve potato, two peanut, and one potato/peanut plots, ranging from 0.2-1.0 acre each, were selected for study. Trapping, baiting and damage assessments were initiated from October 1988 through January 1989. Rodenticide baiting begun after mid-November was too late, and the single baiting was not sufficient to adequately protect the crop. Nevertheless, a lot of information was obtained from the fieldwork. Snap-trapping (2,229 trap-nights including about 25% mouse traps) in and near the plots produced 38 Norway rats (16% of total catch), 90 roof rats (37%), and 116 house mice (47%). In eight plots, damaged plants near harvest averaged about 6.8% of 1,331 plants randomly examined. In two 0.5-acre fields, where both rodent damaged and undamaged potatoes were harvested, 3 of 11 (27%) and 2.5 of 15 (17%) sacks were rodent damaged. [Note: A scheme for correct timing of baiting was agreed upon. Potato (both the 3- and 5-month vines) are not susceptible to rat damage until 1.5 to 2 months after planting, about when corn tassels. By initiating baiting to coincide with corn tassel formation (a very visible sign), corn, potato, and peanut crops would all receive benefits from reduced rat damage provided maintenance baiting continued through harvest.]

Dominica

Cacao

A 43,200-ft^2, 300-tree study site in Hillsborough yielding about 300 lbs/ acre of cacao (dry beans) was cleared of undergrowth in August 1988 and snap-trapped for 2 nights in November 1988. Only roof rats (5) and house

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mice (11) were caught during 100 trap-nights (74 rat-size, 36 mouse-size traps). In September, when the cacao was beginning to mature, rat activity was 12.9% (35 tiles the first night and 50 tiles the second night were set in a 10- x 30-ft grid) and pod damage was 20% (maturing pods on 10% of the trees were sampled). In mid-November, two 20-gram Klerat wax blocks were attached by wire to the trunk 1 meter above ground to each of 150 trees. Bait consumption increased from days 3-14, then declined for 1 week before increasing again from day 21 on. By the end of December (during peak harvest), only 2% of mature pods was newly damaged with very little "fresh" damage observed. This decline in damaged pods, when damage normally would increase, was significant. This site has previously lost up to an estimated 50% of pods. Earlier introduction of baiting (by September) and baiting fewer trees (10%) would probably increase the efficacy and reduce the total amount of bait needed.

Coconut

A 2-acre, 200-palm plot near Tan-Tan that had a history of severe rat damage (up to 90% of fallen nuts having evidence of rat damage) was selected for study. Prior to any fieldwork, grasses and shrubs were cut and fallen nuts were removed. Rat activity in August 1988 was 10% (2 of 20 tiles were positive), and snap-trapping for 1 night with 20 rat traps yielded six roof rats and one Norway rat. Sixteen evenly distributed palms were marked and baited with three-four 20-gram Klerat wax blocks placed by a climber in the crowns of the palms in September and again in October. About 90% of these blocks were consumed 1 month after each placement. However, the November baiting resulted in reduced consumption and, by December, bait consumption was minimal. Newly damaged, fallen nuts were reduced (very few seen) in October after initial baiting in September, and by November, no rat-damaged fallen nuts were observed. Increased nut harvest will not show up until after March 1989. This is because green nuts that survive rat damage (because of baiting) take about 6 more months to mature.

Passion Fruit

Three 0.25- to 0.50-acre plots of passion fruit which have had at least a 30% historical damage level were selected for demonstrating a potential rodent control technique. About 180-208 vine/trunks were present in each plot which were separated from each other by at least 0.5 mile. In one plot (Williams), on November 16, 1988, points located at the top (1.75 meter high) of 55 trunks (about one in four) were baited with two Klerat wax blocks held by wire. Some rat damage was observed at this time. One week later, bait was mostly consumed and an additional 110 wax blocks were added. By December 7, about 50% of this bait was consumed, no damage was observed, and some dead roof rats were found on the ground. Fifty wax blocks were added on December 7, and this final baiting, mostly unconsumed, protected the fruit through the January 1989 harvest period. Baiting in two other plots, started about December 1, 1988, had similar results. As suggested by counterparts, baiting should begin earlier. This would further reduce damage and may reduce overall rodenticide needs.

Urban Rodent Control

A portion of the capital city Roseau, within Ward 5, bordered by Great Marlborough Street (south), Roseau River (north), Queen Mary Street (west) and by Bath Road (east) was selected for study. Fifty-five of about 500 households were inspected and occupants interviewed for evidence of rodent problems. All 55 households had signs of current infestations, such as: (1) nests, smudge marks, fresh droppings, or a clear entry point (45% of households), (2) dead, or evidence of dead, rats (5%), (3) live rats (15%), or (4) burrows (20%). Many households (42%) used rodenticides, snap traps, or a cat to control rats.

Seventy-two snap traps set in 58 households for 1 night (week of September 5, 1988) produced 13 rodents--7 house mice, 3 roof rats, and 3 Norway rats. Twenty-eight (39%) of the remaining traps were sprung, with most (18) of these missing bait. During the week of September 12, 1988, 92 tracking tiles were set for 1 night. Eighteen tiles (20%) showed signs of a rodent visit.

A public education program was conducted by a Dominica interdepartmental team from the Environmental Health Department of the Ministry of Health (MOH) and the Division of Agriculture of the Ministry of Agriculture (MOA). Radio and television (Marpin T.V.) interviews, public meetings, a pamphlet, and a slide show were used.

Control consisted of directly placing Klerat wax blocks in and around households in places where nontarget species would not have easy access to the bait. This was done three times at 3-week intervals from September to November 1988. Total bait used was about 187 lbs (85 kilograms). Cleanup campaigns to reduce harborage and food available to rats in the area were planned but not completed.

Household interviews conducted after the rodent control program was implemented indicated that the rodent control efforts were successful.

Homeowner observation	% of households
More rats	2
No change	8
Significant decrease	60
Hardly any rats seen	10
No rats at all	20
	100

The Dominican team felt that greater success could have been achieved with more manpower, which was necessary for the sanitation work to be done and for soliciting greater community involvement.

Commensal Rodents in Rain Forest

Snap-trapping in two areas (Syndicate and Fresh Water Lake) that were mostly rain forests resulted in catches of only roof rats. Trap success ranged from 6% to 17%, the highest being at Fresh Water Lake, which was about 1 mile from any cultivated area.

Additional Activities

Other crops found to be affected by rats were pumpkin, cucumber, and Irish potato. In some cases, damage was high. Plastic bags covering banana bunches were allegedly being removed by rats exposing the bunches to bird, bat, and insect damage. Informational meetings were held in August and September 1988 for Agricultural Extension Agents at Portsmouth, Hillsborough, Woodford Hill, LaPlaine, and Ground Bay. Radio interviews in English and Creole, three articles in the local newspaper, and one pamphlet helped to increase public awareness of rodent control.

St. Kitts/Nevis

Sweet Potato

Two 0.25-acre sweet potato plots more than 200 yards apart in the Fountain area northeast of Basseterre were used. One was baited three times from August to October 1988 with a total of 5.5 lbs of Klerat wax blocks; the other plot, unbaited. Rat activity on August 2-4, 1988, was almost 20% in the baited plot and over 90% in the unbaited plot. Only Norway rats (one in the baited plot; three in the unbaited) were snap-trapped (30 trap-nights each plot) from the fields. On September 14, the number of damaged potato plants was higher in the unbaited field (about 5%) than in the baited field (about 1%). This was estimated by sampling randomly 10 plants from each of three rows. Harvest was about 300 lbs in the unbaited field and about 500 lbs in the baited field, or 1,200 lbs/acre and 2,000 lbs/acre, respectively.

Pumpkin

Also in the Fountain area, two 0.25-acre pumpkin fields, more than 200 yards apart, were used to compare baited (Klerat wax blocks) and unbaited treatments. From 20 trap-nights in both plots in July 1988, one Norway rat was caught. Rat-damaged pumpkins, estimated by sampling all fruit in three randomly selected rows on September 13, 1988, were greater in the unbaited field (15%) *vs* the baited field (7%). Harvest in September was about 500 lbs in the unbaited field *vs* about 1,000 lbs in the baited field. About 5.5 lbs of rodenticide were used during three baitings from June to September.

Melon

In the Fountain area, two melon fields about 400 yards apart were selected: a 0.06-acre plot, which was not baited, and a 0.25-acre plot, which was baited with a total of 125 20-gram Klerat wax blocks from September 7 through early November 1988. Rat activity using 20 (baited plots) and 12 (unbaited plots) tracking tiles for 2 nights (September 20 and 23, 1988) was 12.5% and 87.5%, respectively. Norway and roof rats were both snap-trapped (3 animals in 20 trap-nights) on September 28 from the unbaited fields. Damage assessment of ten randomly selected plants in each of three random rows on November 1 indicated no rat-damaged melons in the baited plot and 45% damaged (47 fruits) in the unbaited plot. Harvest records showed that about 4,166 lbs/acre of melon were picked (from mid-November to early December) in the unbaited plot and about 8,000 lbs/acre in the baited plot.

Peanuts

One 0.25-acre field of peanuts was baited from late October 1988 to January 1989 with a total of 250 Klerat wax blocks. Rat activity, measured from 12 tracking tiles set on 2 nights in early December, was about 4%; and a damage assessment of 10 randomly selected plants in each of three randomly selected rows resulted in no damage observed. Harvest in January 1989 was about 325 lbs (1,280 lbs/acre) compared to 120 lbs (480 lbs/acre) last year. No snap-trapping was done.

Partial Fieldwork Completed

Some partial fieldwork was completed in Barbados, St. Lucia, and Antigua/Barbuda. A summary of this work is given below:

Barbados

Heavy rains from August to November 1988 and the unavailability of some essential field supplies and materials resulted in a late start for this planned demonstration project. In November and early December 1988 in St. Thomas Parish at Mt. Wilton Plantation, nine sugarcane fields, about 6 acres each and at least 300 yards apart, were designated for study. The West Indies Cane Breeding station offered assistance in selecting the fields. One field was later dropped. Ten snap traps were set in each field for 1 night, and no rodents were caught. Ten tracking tiles were laid out in each field and rat activity averaged 17.5% (0-50%). About 10 kilograms of 20-gram Klerat wax blocks and about 7 kilograms of Racumin mixed in corn flour (0.025% coumatetralyl) were applied in each field. About 70% of both baits was thought to be consumed by rats, 20% by millipedes, and 10% not consumed. The cane was already tall and not far from harvest (2-3 months). The demonstration will be repeated in May 1989, when sugarcane will be at an early crop stage, a better time to begin rat control. (Note: some monkey damage to sugarcane at Portland, St. Peter, was noted during this study.)

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St. Lucia

A 0.5-acre coconut plot of 100 palms with damaged nuts on the ground near Micoud was snap-trapped for 2 nights on February 16-17, 1989. Using 30 rat and 10 mouse traps, 4 house mice and 4 rats (3 roof rats and 1 Norway rat) were caught. Land crabs sprung a good number of traps. Fifty tracking tiles were set on February 15 and 16, but tracks were not easily interpreted. Use of tracking tiles and a program for study over the next few months was outlined.

Limited fieldwork was done in February 1989 in a cacao plot. Three nights of snap-trapping (45 rat and mouse traps set/night) and tile-tracking (50 tiles set/night) were done simultaneously. Nine roof rats and five house mice were caught, and rodent activity went from 94% the first night, and 30% the second night, to 14% the third night. The rat activity reduction was probably a reflection of the snap-trapping removal of rodents from the study area.

Antigua/Barbuda

One vegetable plot (about 1 acre) with melon, corn, and squash (0.25 acre of squash seed was lost to rats, according to Mr. Isaac, the farmer) was snap-trapped with 18 rat traps and 7 mouse traps baited with peanut butter on December 6 and 7, 1988, resulting in one roof rat and 2 house mice being caught. Tracking tiles (17), set for 2 nights on December 7 and 8, resulted in 26% rodent activity. Baiting started on December 13, when 27 Klerat wax blocks were distributed, but no followup was done.

A trip to Barbuda to investigate rodent problems in coconut was made. No rat-damaged nuts were found in a large plantation near the agricultural station. However, vegetable gardens on the island were being damaged. One plot about 1,200 ft^2 with corn, peanuts, sweet potatoes, and beans was chosen for demonstration, and a rodenticide baiting scheme was established for the local agricultural officer to implement.

Conclusions

1. Control of rodent damage to several field crops was satisfactorily demonstrated. This includes cacao on Grenada and Dominica, coconut on Dominica, sweet potatoes on Grenada and St. Kitts, peanuts on St. Kitts, and passion fruit on Dominica.

2. Control of rodent damage to stored foods in large warehouses and smaller structures was adequately demonstrated. This includes large warehouses on Grenada and an urban sector on Dominica.

3. Extension pamphlets now need to be developed and distributed to each country. Pamphlets need to provide simple, illustrated and specific instructions for controlling rodents and reducing damage for specific crops or food storage situations. A short video on rodent control in Caribbean agricultural crops would be very useful, and some basic

reference books on rat and mice control should be provided to MOA libraries or Crop Protection personnel.

4. St. Lucia, Antigua/Barbuda and Barbados need to be encouraged to complete their demonstration projects.

5. Grenada, St. Vincent/Grenadines, Dominica and St. Kitts/Nevis are ready to implement rodent control programs. However, availability of rodenticide is a limitation. If rodenticides can be obtained, selling them at cost will generate funds for purchasing needed rodenticides in the future.

6. The large millipedes on Grenada and Barbados, which consume large quantities of rodenticide bait in the field, need to be identified and a method found to reduce their ability to consume rodenticide bait.

RECOMMENDATIONS

A 5-year Rodent Control Plan

During the next 5 years, there is not yet any planned coordination or opportunities for a review and sharing of information among participating countries. There should be at least a regular (biennial?) gathering of participating individuals to discuss their activities. Additional training, workshops, and short-term technical assistance in specific areas will be needed in those countries (four to date) that have shown capability and interest in rodent control. Without that kind of encouragement, the current investment will probably not yield any lasting impact.

A rodent control plan for each country for the next 5 years is recommended.

Grenada

Cacao is an important crop (about 10,000 acres) that is regularly subjected to significant rat damage. The successful rat control demonstration program showed that rat damage can be reduced to an insignificant level. A Cacao Rehabilitation Project sponsored by the USAID and the Canadian International Development Agency (CIDA), with its own extension officers, is an existing program that could implement rat control recommendations provided by the MOA Pest Management Unit. Corn and sweet potato recommendations for rodent control can best be implemented through extension officers servicing individual farmers.

The Health Department should continue the successful rodent control work initiated by the MOA in the St. George's port area. The Central Market should be included in a similar, regular, maintenance baiting program to reduce rodent damage to food and other goods stored and sold. Sanitation at this market is good, and the baiting program should provide noticeable results within a relatively short time period.

To provide for a sufficient amount of grain bait to mix with coumatetralyl or other rodenticide concentrate, one or two corn farmers could be contracted by the MOA. The MOA could also sell rodenticide products at cost to users to provide funds for additional purchases of rodenticides. The program should begin the first year with a total emphasis on as many cacao plantations as possible. In the second year, remaining cacao plantations can be included and corn and sweet potato farms added. In the third year, all cacao, sweet potato, and corn acreage should be included in the program.

During the fourth and fifth year, other crops susceptible to rat damage, as determined during extension/farmer contacts during the first three years, should be initiated.

St. Vincent/Grenadines

Root crops, namely, sweet potato and peanut fields, in which some corn is usually planted, should be emphasized the first year. Based on the results of the demonstration project completed in January 1989, baiting should begin when the corn tassels, at which time tuber formation in both 3- and 5-month potato vines takes place. Baiting at this time would protect corn during the milk stage and potatoes while tubers are developing. The Ministry can mix bait and sell it at cost to users or provide readymade formulation also at cost. Cacao and coconut could be added during the second year. Cacao is grown on a very small acreage and would not require much time and effort. Crown-baiting in coconut (with larger acreage) should also be added the second year. Although no demonstration in either crop has been done, results from Grenada and Dominica on cacao and coconut indicate that the methods used there will also be effective on St. Vincent.

During the third year, all root crops, cacao, and coconut acreage should be included in the program. Food and feed storage sites with rodent problems can be added during the fourth year and any other crop found to have had significant rodent losses during the three previous years could be added in the fourth and fifth years.

St. Lucia

Rodent control demonstrations need to be completed in priority crops. When effectiveness has been demonstrated on a small scale, the extension of the methods on a larger scale can take place. The outline of planned field demonstrations developed by St. Lucian trainees at the Grenada training course (copy in second trip report) provides for an adequate demonstration of cost/effective rodent control.

The first year should include cacao plantations and involve the St. Lucia Agricultural Association which has two field officers who can help with implementation. Sweet potato and peanut crop rodent control programs can also start the first year since smaller acreages are involved.

In the second year, coconut acreage can be added. A major effort should include cooperation with the St. Lucia Coconut Growers Association. Although no field officers are available from this Association, administrative help will be useful. The third year should be used to complete and/or strengthen work in cacao, root crops, coconut, and additional crops with known rat problems; this may include citrus (debarking by rats), melons, and coffee.

Strengthening and improving rodent control efforts in croplands from the first three years should take place in the fourth and fifth years. Food storage problems involving rodents should be added during years 3 and 4. The MOH should concentrate on urban rodent problems at the port area (see Grenada's successful program), government institutions, and individual homeowners beginning in year 1. The Central Market needs a concerted effort of regular, consistent rodent control. The MOH should implement the specific steps recommended for rodent control at the Central Market by the consultant during this last visit.

Dominica

The first year should involve extension of the methods used in the successful rodent control demonstration projects in cacao and passion fruit. Also, during the first year, demonstration projects in sweet potato and banana (loss of plastic bags allegedly due to rats) should be done on a small scale.

During the second year, rodent control in coconut acreage can be started; and if the demonstration projects in sweet potato and banana warrant, these crops can be included. The third year should be used to strengthen the activities of the first two years and to add small-scale rodent control demonstrations in vegetable and coffee plots.

In the fourth year, operational programs should be fully implemented in all major crops adversely affected by rodents. The fifth year can then be spent monitoring these efforts for continued effectiveness and/or improvement.

The Dominica Coconut Products, Inc., the Banana Growers Association, and the cooperatives should be enlisted to help implement these programs.

The MOH, from the first year on, should implement rodent control programs at the port area (see Grenada's successful program) and other public institutions. A maintenance rodent control effort should be continued in Ward 5 of Roseau to keep rodent infestation minimal.

Antigua/Barbuda

Rodent control demonstration projects in priority crops need to be completed, particularly in corn and vegetable crops. Food and feed storage, particularly at livestock operations, should also be included in rodent control demonstrations. Barbuda coconut currently has no rodent problems, but vegetable gardens do. Since agricultural crops involve less acreage on Antigua compared to other east Caribbean countries involved in this project, it should not require 5 years to implement large-scale rodent control programs in priority crops. There is some pineapple grown that is reported to be damaged by rats. This should be investigated to verify and determine the significance of the damage.

St. Kitts/Nevis

The four crops used in the demonstration--sweet potato, peanut, melon, and pumpkin--all indicated reduced rat damage and activity and increased yields when rodenticide was used. Although sugarcane is the dominant agricultural crop on St. Kitts, it is not a crop in which the MOA chooses to invest any effort for rodent control. Therefore, the 5-year plan will not include any emphasis in sugarcane.

The first year should include an expansion of farmer involvement by area or district. Because of limited manpower within the MOA, only one or two districts should be included the first year. All sweet potato, peanut, melon, and pumpkin growers should be solicited to participate, and they should be visited periodically to monitor their rodent control efforts. Remaining districts can be added in the subsequent years, after rodent control programs are well established in the district(s) chosen initially.

Rodenticide will have to be supplied or sold at cost to farmers during the early years to encourage interest and use. Details of how to use this rodenticide should include amount, timing, and frequency to avoid using too little or too much rodenticide. The tendency is to use too much, too frequently. By selling bait to farmers and giving specific instructions as to how to use it, the costs should become more important, resulting in more effectiveness (larger yields at less cost).

Other crops also found to be significantly damaged by rats may be added after the third year. Activities on Nevis should be initiated by this time if not already started.

Barbados

Demonstrations in several sugarcane fields need to be completed in order to gather some baseline data or information from which to draw on to make specific recommendations. Sugarcane is a crop which is in the field a long time with a long period of susceptibility to rat damage. Baiting schedules must be determined so that the labor and bait costs do not exceed the benefits of increased yields. This is particularly important now with low sugar prices.

Therefore, this first year should be a time for gathering information on what species are present and when do rodent populations increase and/or move into cane fields. When does damage begin, how much bait should be used, and how and where should it be placed for maximum protection of the crop? The planned fieldwork for this year should begin to answer these

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questions, but it may take another crop/year to provide results that will lead to cost-effective recommendations.

Large areas in which these recommendations can be tested should be used in the third year and, if successful (costs of control should be much less than increased yields), the program can be expanded to the rest of the island in the fourth and fifth years.

The best information available now indicates that initial baiting should begin at the perimeter of cane fields at the beginning of the crop season (about May/June). The previous harvest and dry season combine to naturally reduce rodent populations. By initiating baiting near the beginning of the crop season, when conditions favoring rat survival start to improve, the rat population will be suppressed (at a time when it would normally increase) enough to limit damage during the susceptible period from about August to harvest (February to May). The frequency of baiting, how much bait to use, how the bait should be placed, and whether or not perimeter baiting can be used exclusively are the major unanswered questions. These must be answered before cost-effective rat control can be done.

APPENDIX I

ITINERARY

Date	Location	Activity
February 8	Denver, Colorado, to Miami, Florida	Travel
9	Miami to Barbados	Travel
10	Barbados	FAO briefings and Ministry of Health (MOH), Barbados Sugar Industry, Ltd. meeting
11	Barbados	On duty
12	Barbados to Grenada	Travel
13	Grenada	Ministry of Agriculture (MOA) briefing and review fieldwork; MOH briefing
14	Grenada	Field visits; MOA and MOH joint session
15	Grenada to St. Vincent	Travel; briefing, review of fieldwork, future work plans
16	St. Vincent to St. Lucia	MOH, briefing; MOA, fieldwork summarized; travel
17	St. Lucia	MOA briefing, field visits
18-19	St. Lucia	On duty
20	St. Lucia to Antigua	MOH, briefing and field visits; travel
21	Antigua to Dominica	Travel; MOA briefing, review fieldwork; MOH, review fieldwork planning session
22	Dominica to Antigua	MOA, field visit, final briefing; travel
23	Antigua	MOA, briefing; MOH, briefing; review fieldwork

APPENDIX I (Continued)

Itinerary

Date		Location	Activity
February	24	Antigua	To Barbuda to identify rodent problems and return
	25-26	Antigua to St. Kitts	Travel; on duty
	27	St. Kitts	MOA and MOH briefing and demonstration site visits
	28	St. Kitts; to Barbados via Antigua and St. Lucia	MOA briefing and review of field data; travel
March	1	Barbados	MOH, review fieldwork; FAO briefings; Medical Research Council, leptospirosis project
	2	Barbados to Denver, Colorado via Miami, Florida	Travel

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APPENDIX II

PERSONS CONSULTED

Name	Organization	Function
	Grenada	
P. Steele	Ministry of Agriculture (MOA)	Permanent Secretary
E. Boyke	Ministry of Health (MOH)	Permanent Secretary
P. Graham	MOA	Pest Management Unit Plant Quarantine Officer
T. Beddoe	Food and Agriculture Organization (FAO)	Consultant with MOA
R. Harford	MOA	Pest Management Unit Plant Protection
C. Dominique	MOA	Chief Technical Officer
C. Edwards	MOH	Chief Environmental Health Officer
A. James	MOH	Senior Public Health Officer, Rodent and Rabies Control
	St. Vincent/Grenadines	
P. Isaacs	MOA	Agricultural Officer, Plant Protection
M. Eustace	MOH	Chief Medical Officer
S. Lynch	MOA	Agricultural Assistant, Plant Protection
E. Shortte	MOH	Public Health Superintendent
A. Edwards	MOH	Chief, Insect Vector Control Program

APPENDIX II (Continued)

Persons Consulted

Name	Organization	Function
	St. Lucia	
Hon. F. Henry	MOA	Minister of Agriculture
P. McDonald	MOA	Permanent Secretary
A. Desir	MOA	Director, Agricultural Services
D. Demacque	MOA	Chief Agricultural Officer
E. Henry	MOA	Senior Crop Protection Officer, Crop Protection Unit
Mr. Ferrier	MOH	Chief, Public Health Inspection
W. Gabriel	MOH	Public Health Inspector, Environmental Health Unit
Mr. Charlemagne	Port Authority	Deputy Director
M. Faucher	MOA	Extension, Research, Soufriere
R. George	MOA	Extension Officer, Micoud
	Dominica	
C. Bully	MOA	Chief Agricultural Officer
E. Harris	MOA	Deputy Chief Agricultural Officer
M. Thomas	MOA	Agricultural Instructor, Crop Protection
D. Ferreira	MOA	Crop Protection
A. John	MOA	Coffee Development Project
B. Johns	MOA	Cocoa Field Assistant
B. Xavier	MOH	Environmental Health Officer

APPENDIX II (Continued)

Persons Consulted

Name	Organization	Function
	Antigua/Barbuda	
E. Benjamin	MOA	Permanent Secretary
F. Henry	MOA	Director of Agriculture
A. Grant	MOA	Extension Officer
J. Reid	MOH	Chief Health Inspector
A. Morris	MOH	Rodent Control
Mr. Williams	MOH	Public Health Inspector
M. John	Barbuda Council	Agricultural Officer
	Kitts/Nevis	
E. Petty	MOA	Permanent Secretary
K. Archibald	MOA	Chief Agricultural Officer
J. Thomas	MOA	Head, Crop Protection, Research
T. Jackson	MOA	Extension Division, Research
Mr. Hodge	MOH	Chief Public Health Inspector
	Barbados	
A. W. Vaughn	MOH	Director, Veterinary Public Health
R. Arthur	MOH	Chief Rodent Control Unit
M. Marshall	Barbados Sugar Industry, Ltd.	Field Officer
T. Rudder	Barbados Sugar Industry, Ltd.	Technical Management
C. Everard	Medical Research Council	Leptospirosis Research
B. Patterson	FAO	Acting Representative
T. Watanabe	FAO	Associate Program Officer
V. Best	FAO	Administrative/Finance Assistant

TRIP REPORT*

BANGLADESH and PAKISTAN

March 29-April 15, 1989

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May 11, 1989

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ITINERARY

Date	Location	Activity
March 29-31	Denver, Colorado, to Dhaka, Bangladesh	Travel
April 1-8	Dhaka	Assist in developing and planning Project activities and training needs with Project personnel, USAID, and BARC. Begin preparation for upcoming External Review.
April 8	Dhaka to Islamabad, Pakistan	Travel
April 9-13	Islamabad	Assist in developing Concept Paper for Project extension and exploring resource support options for Project continuation.
April 14-15	Islamabad to Denver, Colorado	Travel

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OBJECTIVES

Bangladesh: To review current research activities of Project staff and counterparts; to begin preparation for an External Review of the U.S. Agency for International Development (USAID)-funded Vertebrate Pest Management Component of the Agricultural Research Project; and to organize team planning of Project activities through June 1991.

Pakistan: To investigate the feasibility of continuing the Vertebrate Pest Control Project (VPCP) component after June 1990 when AID/Islamabad funding under the Food Security Management Project ends, and to examine options for continuing Denver Wildlife Research Center (DWRC) assistance to vertebrate pest management in Pakistan.

SUMMARY

Bangladesh: Plans for an External Review of the Project's activities and accomplishments since its inception in 1978 began to take shape. The Review was scheduled for July 1989. Possible team members were identified, and USAID confirmed that the Scope of Work drafted in 1988 would be used. An agreement was reached that the Project would attempt to implement a large-scale pilot demonstration trial to evaluate the technical efficacy and socioeconomic acceptability of a strategy for rodent control in rice.

Pakistan: A Concept Paper and a supporting budget to continue DWRC assistance to the National Agricultural Research Centre (NARC) Vertebrate Pest Control Project from June 1990 until September 1993 was prepared and presented to AID/Islamabad for consideration.

BANGLADESH

Background

DWRC technical assistance to the Vertebrate Pest Control Laboratory (VPCL) at Bangladesh Agricultural Research Institute (BARI) through funding support by AID/Dhaka began in December 1978. Dr. Michael Jaeger is the third resident DWRC technical adviser to this Project. Dr. Jaeger arrived in Bangladesh in October 1986; Mr. Richard Poché (1979-81) and Mr. Joe Brooks (1981-1985) preceded him. The overall objectives of this Project have been to identify vertebrate pest problems; evaluate control techniques; develop strategies to manage vertebrate pests; and train staff and develop an institutional identity for VPCL, all leading to institutionalization of a vertebrate pest management (VPM) research capacity in Bangladesh.

USAID support for the Vertebrate Pest Management Component under the Agricultural Research II Project will continue until June 1993. The current plan is for Dr. Jaeger to continue as the in-country Project Leader until October 1990 (a 4-year residence period), at which time he will return to the United States. DWRC will then continue to coordinate the Project until June 1993 using short-term TDY's. This plan will provide a mechanism through which DWRC and the VPCL can maintain an effective cooperative relationship so that research, training, extension, and other areas of mutual interest and concern can be implemented. This approach will also establish more direct staff interaction between VPCL and DWRC to facilitate a continuing professional network for VPCL after the Project is completed.

Implementing Rodent Control

As the above chronology indicates, DWRC technical assistance is entering a new phase. The current accepted work plan, which was developed in 1986, with input by AID/Dhaka, Project counterparts, and DWRC emphasized activity into the three areas of vertebrates felt to have the greatest impact on Bangladesh agriculture--preharvest rat damage to rice, rodent damage to grain and other food stored in houses, and possible jackal damage to poultry and sugarcane. The work plan was developed to systematically and objectively look at the interrelationships of these three pest situations until September 1988 and then begin field evaluation and implementation of control methods for the remainder of the Project. For the preharvest rodent problem, rodenticide evaluations were begun with Bangladesh Agricultural Research Council (BARC) Extension Specialist in October 1988 in aman rice. A plan is now being developed to continue field evaluation of this strategy on a much larger scale in September and November 1989.

During my TDY, the format for a strategy to evaluate rodent control in aman rice was developed. It was decided to design and implement a large-scale pilot demonstration trial that would permit scientific evaluation from an efficacy standpoint, and farmer acceptance evaluation from a socioeconomic standpoint. DWRC and VPCL Project personnel will work closely with personnel of BARC, who will coordinate this demonstration, and the Department of Agricultural Extension (DAE), with the USAID-funded Farming Systems Project, to identify trial sites and socioeconomic input. It may also be possible to work with Mini-Industrial and Development Systems (MIDS) Project for rodenticide bait production. This demonstration will attempt to extend developed technology to Bangladesh farmers through what AID/Dhaka terms an Accelerated Technology Transfer process. Therefore, this pilot demonstration trial will test both a rodent control strategy and the complex process of implementing it.

DWRC may be able to directly support this activity by providing (1) an extension wildlife biologist from USDA Extension Service to help DAE specialists get farmers involved in the demonstration and (2) a wildlife biologist with experience in rodenticide evaluation to help collect efficacy data. A Study Protocol is being developed.

External Project Review

During early 1988, Dr. Jaeger pointed out to Mr. Kevin Rushing, the AID/Dhaka Agricultural Development Officer at that time, that it might be advantageous to maintain the Project (in some form) past its June 1991 termination date, and that a Project evaluation might be appropriate. Although the Vertebrate Pest Management Component was reviewed in 1983, 1985, and 1987 as part of the overall Agricultural Research II Project (and found to be performing well), it has never had its own in-depth review. Mr. Rushing agreed, and favored a formal External Evaluation which would include both technical and infrastructural components and provide recommendations as to the future direction (if warranted) of additional VPM activities.

A Scope of Work for an External Review was drafted by Mr. Allen Hankins in 1988, a three-person review team has been tentatively identified, and a tentative date set for July 1989. The Review will be conducted for about 2½-3 weeks in Bangladesh and another 2-3 days at DWRC. DWRC will provide all Project background documents deemed necessary by AID/Dhaka prior to the departure of the team to Bangladesh. Much has been accomplished in terms of facilities construction, pest species definition, evaluation of control techniques (including copper oxychloride as a seed repellent to myna birds, Bird-Scaring Reflecting Tape® [1] to protect crops from parakeets, and zinc phosphide bait cakes to control rodents in wheat), and implementation of management strategies. More intensive institutional development activities need to be initiated to assure that the VPCL within BARI continues to function effectively beyond the life of the Project. The upcoming pilot demonstration test should provide a good guidepost by which to evaluate the extent of the VPM institutionalization process.

Other Activities

1. Just prior to my arrival, BARC organized and coordinated a workshop on the Status of Vertebrate Pest Research in Bangladesh. Participants included scientists and other personnel from BARI; Bangladesh Rice Research Institute (BRRI); Dhaka, Bangladesh Agricultural, Chitagong, and Rasahid Universities; Bangladesh Agricultural Development Corporation; and DAE. The purpose of this gathering was to bring together individuals from organizations involved in VPM in Bangladesh, look at data being gathered, review progress being made, and make recommendations relative to: (a) the currently available control methods, (b) the priority of research, and (c) the extension and transfer of technology. A workshop proceedings is being prepared. A committee was also established to recommend direction, needs, and priorities in VPM. This committee could be an important conduit for coordinated, VPM activities in Bangladesh in the future.

2. During this TDY, I met with, among others, Dr. M. M. Rahman, Executive Vice Chairman, BARC, to address his concerns about the Project's direction; Mr. Keith Byergo, Project Manager of CHECCHI, the new contractor for the Umbrella Project under which the Vertebrate Pest Management Project is a component, to determine how the Vertebrate Pest Component can best use the CHECCHI support; and Dr. Ray Morton, the AID/Dhaka Agricultural Development Officer, to brief him on DWRC capabilities and discuss Project direction.

[1] Reference to trade names does not imply endorsement by U.S. Government.

3. In addition, a number of other issues were discussed or plans developed for the following:

(a) Participation by VPCL scientists in the Colorado State University/DWRC "2nd International Short Course in Vertebrate Pest Problems and Solutions in Developing Countries," to be held at Fort Collins, Colorado, on August 14-27, 1989.

(b) Development of a 2-week hands-on training program for one VPCL scientist in coyote management activities with Dr. Frederick F. Knowlton, Wildlife Biologist, DWRC Predator Control Research Section, in Logan, Utah, during August 1989 prior to the Short Course.

(c) Provision by the DWRC Analytical Chemistry Section of a validated method for analyzing zinc phosphide at VPCL.

(d) Development of a tentative schedule for TDY technical assistance to the Project in (1) evaluating the technical efficacy of the pilot rodent control demonstration, (2) preparing and implementing extension and training materials activities during the demonstration, (3) providing training to Project personnel in data input and statistical analysis using SAS once the Project computer is installed, and (4) trapping, radio-equipping, and censusing jackal and jungle cat populations.

(e) Preparation of video tapes of Project and VPCL activities.

(f) Construction of a rodent breeding and testing facility at the BARI/VPCL.

(g) Briefing presentations by VPCL scientists at AID/Dhaka.

(h) Preparation by Dr. Jaeger of a Concept Paper which describes past Project accomplishments and clearly defines future Project activities and their rationale to help ensure a viable VPCL with which DWRC can continue to collaborate as a "sister research institution" after completion of the Project.

(i) Initiating training for Project personnel in Management of Agricultural Research. USDA Office of International Cooperation and Development (OICD) conducts such courses and could arrange to provide them in the host countries. It might be possible to organize one such course (perhaps through CHECCHI) in which appropriate individuals from both the Bangladesh and the Pakistan Projects could participate.

PAKISTAN

Vertebrate Pest Project Overview

The Vertebrate Pest Control Project (VPCP) with the DWRC was initiated in March 1985 and staffed by Mr. Joe Brooks, DWRC Project Leader, in November 1985 under the Government of Pakistan (GOP) and USAID Post-Harvest Management Component of the Food Security Management (FSM) Project. The initial objectives of the VPCP were:

1. Assist the four Provincial Food Departments in Sind, Punjab, Baluchistan, and North-West Frontier Province (NWFP) to strengthen their capabilities in vertebrate pest control operations and loss assessment methods in grain storage facilities.

2. Assist the Pakistan Agricultural Storage and Services Corporation (PASSCO) to strengthen and improve their vertebrate pest control operations and loss assessment methods in grain storage facilities.

3. Improve the quality of adaptive research programs for stored grains.

4. Assess the problems of vertebrate pest-caused losses of stored grains at farm level and develop methods to reduce losses.

5. Assist the Pakistan Agricultural Research Council (PARC) to strengthen the capabilities of their pest control laboratories at Karachi and Islamabad and upgrade the applied research program in bird and rodent control in stored grains.

In January 1986 the Joint Secretary for Food in the Ministry of Food, Agriculture, and Cooperatives asked USAID for assistance and recommended that the VPCP also work on preharvest problems, particularly those with which farmers find it hardest to cope. In a series of field surveys carried out in sugarcane, wheat, maize, and groundnut crops in 1986, the VPCP found that preharvest losses of grains and other crops were more serious than losses in storage facilities. This added another objective to the program:

6. Assess major vertebrate pest problems in preharvest crops and attempt to implement operational pest control in pilot and large-scale trials. Develop safe, effective, and inexpensive methods that farmers can use to protect their crops from animal damage.

This preharvest activity was initiated in early 1987, while still trying to complete the survey management and training aspects of the postharvest activity.

Funding support for vertebrate pest management (VPM) under FSM terminates June 30, 1990. The ongoing stored grain loss surveys and evaluation of postharvest pest problems, development of control methods, training activities, and implementation of management programs should be completed during the remaining 14 months of the FSM Project. The GOP has implemented Project postharvest recommendations. Reduced losses in stored foods in

Pakistan from effective vertebrate pest control methods will be demonstrated.

Preharvest Pests--Background

The problems of vertebrate pest damage to crops in preharvest situations are only just beginning to be addressed by the VPCP. Implementation of effective, safe, appropriate VPM is complex and requires several years of research into pest status, laboratory and pilot field trials of possible control methods, documentation of control demonstration results over representatively large areas, and training and extension activities, all of which lead to indigenous capabilities and eventual institutionalization of VPM.

The important vertebrate pests to preharvest agriculture in Pakistan have been identified and prioritized according to the amount of damage they cause annually. Ten species of rodents, two lagomorphs, the wild boar, and nine species of birds are responsible for about 95% of the vertebrate pest damage in Pakistan agriculture and forestry. The order of importance of the several pest groups are:

1. Preharvest rat and mouse damage to ripening wheat, rice, and sugarcane.

2. Preharvest wild boar damage to sugarcane, maize, wheat, sorghum, and rice.

3. Preharvest pest bird damage to sunflower and other oilseeds, maize, wheat, rice, and soft fruits.

4. Porcupine damage to forestry seedlings, maize, and orchards and root crops.

5. Preharvest vertebrate pest damage to groundnuts and other oilseed crops.

Some methods to control rodents in wheat and rice were developed in previous national and regional projects and are ready to transfer to farmers, but methods to control the other vertebrate pests still need development. Basic research studies on the biology and behavior of wild boar, porcupine, parakeet, pika, and voles are needed in order to develop safe, effective, and appropriate control methods and management strategies. Some socioeconomic evaluations of farmer acceptance and use of control techniques may be appropriate. Development of training and extension materials to transfer technology to extension workers and farmers are not yet implemented but vitally needed. Institutionalization of vertebrate pest management in Pakistan in the agricultural research system, in the agricultural extension system, and in the agricultural universities system has been initiated but not yet fully developed and implemented.

A decision is needed whether to continue this work beyond June 1990 and, if so, under what conditions and with what expected results. It is important that this decision be made soon to (1) promote mutual understanding of the Project's goals, (2) develop realistic, objective timeframes within which to accomplish them, and (3) permit sufficient time to integrate VPCP activities with those of the Pest Management Research Institute's (PMRI) Vertebrate Pest Control Research subunit which will be based at NARC beginning in June 1989. The PMRI has prepared a draft PC-1 for their preharvest program. Therefore, the main objective of my TDY was to determine if interest exists by the GOP and USAID in continuing to support preharvest VPM and, if so, in what manner. In a meeting with Dr. Patrick Peterson (Supervisory Agricultural Development Officer), Mr. Thomas Olson (Agricultural Economist), Ms. Linda Raver (OICD), Mr. Joe Brooks (DWRC Project Leader), and myself, Dr. Peterson expressed his support of past Project activities and his desire to continue to support it from July 1990 until September 1993. However, for several reasons, he requested that DWRC explore the feasibility of maintaining this Project through backstop and TDY support from DWRC, and not through a Resident Project Leader. The positive and negative aspects to effectively implement a preharvest research project in its early phases under these conditions were explored relative to the amount of resources needed. A Concept Paper "Preharvest Vertebrate Pest Management in Pakistan--A Draft Proposal" with a tentative budget was prepared. Based on this Concept Paper, the Project would consist of the following:

Project Description

Followup activities would be structured into three phases, beginning July 1990 and possibly ending about September 1995. Research, training, demonstration, and implementation activities would occur in all phases, but during Phase I (July 1990-June 1992), continued research and methods development into preharvest pest problems would predominate, but technology already developed will be field evaluated. During Phase II (July 1992-September 1993), implementation of developed strategies and methods through pilot schemes and large-scale control efficacy demonstrations with socio-economic and cost:benefit aspects would be emphasized. These activities would be conducted within the framework of the Management of Agricultural Research and Technology (MART) Project through Project coordination and extensive TDY's from DWRC. During Phase III (October 1993-September 1995, technology transfer and information dissemination through training and the use of multimedia extension methods for agricultural extension workers and farmers would be emphasized. At this point, Phase III is not funded but could be perhaps covered, in part, by TDY's using any Project savings.

Phases I and II, because of their emphasis on collecting objective scientific information on which to base eventual control strategies, would be most effectively covered by having a DWRC adviser in-country for the duration of each phase. However, because of constraints imposed on the number of in-country advisers at USAID, the Project will be designed to operate using DWRC backstop support and a full-time Project Coordinator based at DWRC to coordinate the research, training, and implementation activities of the Project through TDY's and the activities of the USAID Personal Services Contract (PSC) staff at Islamabad. At least 6 man-months of TDY's per year will be provided through four to five TDY's each year. Overall work plans will be worked out with the GOP scientific officers and will be checked and revised as appropriate with the USAID Vertebrate Pest Laboratory staff during each TDY visit. Goals will be established by which to measure Project progress and achievements and will be evaluated for success before moving to the next phase. Data tabulation, analysis, and report writing will be done in cooperation with Project scientists during TDY's and/or by the Project coordinator at DWRC, as appropriate.

This will be the first time DWRC has tried to implement an early-phase research project without an in-country adviser; nonetheless, we hope that this proposal will provide a logical framework within which to obtain the information needed to develop appropriate and effective vertebrate pest control strategies that will eventually result in an indigenous capability to implement these strategies.

Other Activities

1. The VPCP is in the process of monitoring a large-scale rodent control demonstration that was initiated in Gujrat District. Four sets of 30 fields are being monitored monthly throughout the wheat season (January-May) to determine rodent infestation, damage, and eventual yield. In addition, an attempt is being made to involve field assistants of the Crop Maximization Programme (CMP) to motivate farmers to use ready-made baits containing either zinc phosphide or coumatetralyl. Training was offered to farmers using slides, videos, and posters.

2. Just prior to my TDY, Mr. Brooks and his counterpart scientists completed their 1989 VPM Training Course. Fourteen individuals representing Syria, Uganda, and Pakistan participated. This is an annual course provided by NARC, with whom DWRC collaborates to implement Vertebrate Pest Management in Pakistan.

3. During my TDY, Project staff were involved in a 1-week course on video Production and Editing Techniques. This training course covered topics such as the applicability of videos to agriculture, how to use Camcorders, lighting, audio, and editing techniques. A 3-minute video they prepared as a final project on rodenticide baiting received a very favorable critique. It is a course that would also be useful to the AID/Dhaka-supported BARI research projects.

4. Several steps have been or are being taken to assume that VPM eventually becomes institutionalized in Pakistan. A draft document was recently prepared to officially include Vertebrate Pest Management in the NARC master plan. Plans are being developed with the PMRI for cooperation in work plans, surveys, and training and with the University of Faisalabad to initiate a VPM curriculum; the Project already supports VPM thesis research at this University. In addition, the VPCP is strengthening linkages with CMP, the Barani Agricultural Research and Development (BARD) Programme, the Technology and Transfer Unit, the Training Institute, and the Farming Systems Research (FSR) at NARC, among other groups.

5. Finally, plans are being made to provide a Project scientist with hands-on experience in field evaluation of a vertebrate pesticide and laboratory analysis of chemicals at DWRC prior to this individual conducting such research toward a Ph.D. in Pakistan, under NARC Scientist Dr. Abdul Jabbar.

CONTACT AND ACKNOWLEDGMENTS

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TRIP REPORT*

M O R O C C O

March 31 - April 9, 1989

by

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April 26, 1989

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ITINERARY

Date	Location	Activity
Mar 31-Apr 1	Denver, Colorado, to Rabat, Morocco	Travel
Apr 2-7	Morocco	Planning for training in ecotoxicological methods and research to evaluate environmental effects of locust insecticides.
Apr 8-9	Rabat to Denver, Colorado	Travel

OBJECTIVES

This TDY was to assist the U.S. Agency for International Development (USAID) and the Government of Morocco (GOM) in preparing a proposal for training in methods and research on the environmental effects of organophosphate insecticides used in locust control. Both organizations recognize the importance of locust control, but are anxious to ensure that the programs do not harm the environment. They also want to provide training in ecotoxicological research for Moroccan scientists so that they can evaluate other programs of pesticide use in the future.

TDY ACTIVITIES

Like other countries in Africa, Morocco recently has undertaken intensive use of insecticides to control locusts and thereby protect valuable agricultural crops and rangeland. Between April and June, and again between November and December, 1988, over 2 million ha were treated south of the Atlas Mountains in Morocco. Most applications were of organophosphate insecticides, including malathion, fenitrothion, DDVP, fenthion, and diazinon. Lesser amounts of synthetic pyrethroids and the carbamate, carbaryl, were also used. All of these materials are broad spectrum insecticides, capable of killing most arthropods and thereby disrupting the community ecology of invertebrates and vertebrates on treated areas. Except for malathion, the organophosphates used are also capable of causing mortality in birds under the right conditions.

On April 3, I joined Bob Hellyer at USAID and we proceeded to the Central Command Post for locust control in Rabat. We were met there by Mr. Arifi, Director, Direction de la Protection des Végétaux des Contrôles Techniques et de la Repression des Fraudes (DPVCTRF) and his staff in the Service de la Protection des Végétaux that are concerned with locust control (see Attachment 1). I described the Denver Wildlife Research Center (DWRC), its staff, and its programs. As the Moroccans that were present are responsible for control of vertebrates as well as locust and other insects, they were also interested in our work with birds and rodents. I then outlined our research capabilities in chemistry, physiology, electronics (radio-tracking) and with birds and mammals to evaluate insecticide effects on the environment. Mr. Arifi asked that we meet with his crop protection staff the next day and develop a proposal for training in ecotoxicological methods and field research to determine the effects of locust control in Morocco.

Bob Hellyer and I met again with the Moroccan scientists on April 4. We prepared a scope of work after considering the kinds of organisms to be studied, the approaches to be followed, and the methods to be used. This proposal included training in residue chemistry, in the measurement of cholinesterase inhibition, and the abundance, mortality, movements and changes in food habits of birds and mammals on experimental areas. Studies of other vertebrates (fishes, reptiles, amphibians) were not included, but can be studied later after Moroccan scientists are trained. Training in arthropod abundance, mortality and ecology were included, but not training in study of other invertebrates, soil micro-organisms, and soil nitrification and ammonification processes that could be affected by insecticides. Studies on plant effects were not included. It was decided that evaluations would be made of experimental applications of malathion and DDVP to study plots, both at the recommended rates and at two times the recommended rates.

Treatments will be made by GOM. It is hoped that locusts will be abundant on study plots when they are treated, but applications of insecticides will be made irrespective of their presence. The primary objective of this work is to evaluate effects on the ecosystems where insecticides are applied. To do this, measurements must be made of the kinds of organisms present and their relationships before and after spraying. These kinds of studies can only be done on experimental plots. In operational control, applications are made where locusts are present and spraying is done immediately after bands or swarms are located. Therefore, time is not available to obtain good pretreatment data on the ecosystem. Important information can be obtained by evaluating effects of operational control where locusts are present, but such work has a different objective than studies described here.

Consideration was also given to evaluations in areas where locust are present, to studies in areas heavily treated in operational control programs, to studies of individual species such as ibis, storks, bustards and raptors, and to specific habitats such as wetlands. However, it was agreed that those investigations could be done at a later time after techniques were mastered through research on experimental plots.

On Wednesday, April 5, I drove to Casablanca with Mohamed Daia, chemist DPVCTRF, to visit their Laboratoire Officiel d'Analyses et de Rechercher Chimiques. At the laboratory we met with the Director, M. El-Maâti Benazzouz, and chemist, M. Mostafa Tarhy. In discussion we learned the lab routinely analyzes commercial pesticides, food products and environmental samples for organophosphate insecticides. They expressed a desire for information on methods and for demonstration of analyses of animal tissues. They have a number of trained chemists and technicians, and the current capacity of the laboratory is restricted mostly by the limited number of gas chromatographs available. Current equipment is 15 years old and outdated. Dr. Benazzouz agreed it would be possible to provide residue analyses for our studies if a gas chromatograph and a freezer to store samples could be made available.

On April 6, I wrote the proposal for cooperative work between GOM and DWRC. It was translated, typed, and distributed to members of DPVCTRF for their review. Joe Kitts, USAID locust coordinator, and I also met with Mohammed Aissi and Ramona Muller, U.S. Peace Corps. We discussed the program USAID and the GOM were developing and asked about the possibility of one or two Peace Corps volunteers being assigned to help with training and provide continuous in-country coordination between DWRC and GOM. Mr. Aissi thought such an arrangement might be possible and of benefit to GOM and the volunteers. He will explore the possibility of obtaining volunteers with biological backgrounds to assist in this activity by late 1989.

On Friday, April 7, Bob Hellyer, Joe Kitts, and I again met with Mr. Arifi, Mr. Lahtar, and their staff. The GOM offered additional comments during a review of the proposal. Mr. Arifi stated he liked the proposal and felt a relationship with DWRC should be initiated. He mentioned that in the future he would like to explore with USAID a broader cooperative program with DWRC that would continue pesticide evaluations, address other environmental issues, and improve measurement and control of vertebrate pest damage. I later again revised the proposal to include the additional comments, and Bob Hellyer gave it a final editing. Mr. Hellyer stated he felt the proposal would provide needed training for GOM and give a good initial assessment of the environmental effects that result from locust control with malathion and DDVP. A copy of this proposal is enclosed (Attachment 2).

The final proposal will now be reviewed by GOM, USAID, Peace Corps, and DWRC. If all agencies approve the proposal, I will prepare a list of DWRC trainers and a schedule for training courses. At that point the GOM will assign appropriate responsibilities to their staff members, and plans of work can be developed.

CONTACTS MADE WHILE IN MOROCCO

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Mr. Joe Kitts, Locust Coordinator
Mr. Eric Loken, Agricultural Officer
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f. Mammal identification and methods to assess abundance, foods, and behavior. — 3 weeks

g. Bird identification and methods to assess abundance, foods, and behavior. — 3 weeks

h. Invertebrate identification and methods to assess abundance and community ecology. — 4 weeks

3. <u>Skill Development</u>

Skill development by GOM scientist in the use of the above techniques will be accomplished by planned investigations in study areas during two periods, June-July 1990 and again during August-September 1990. After each period of collection of this baseline information, results will be reviewed and evaluated by the multidisciplinary team, including a 2-week visit by a DWRC scientist. — 4 weeks

4. <u>The Experiment</u>

Experimental plots will be treated with two insecticides (Malathion and DDVP) about November 1, 1990. Spray applications will be made by GOM. Pre- and posttreatment data will be collected during 3 weeks in October and 3 weeks in November, respectively. Data to evaluate treatment effects on vertebrates will be obtained using ecotoxicological skills acquired during training and skill development phases. Three DWRC scientists will assist in the exercise for the 6 weeks each. — 18 weeks

5. <u>Report Preparation</u>

Two weeks will be scheduled in early 1991 to evaluate results and make assignments for preparing a final report. One DWRC scientist will assist for the weeks. — 2 weeks

<u>Total</u> — 50 Person-Weeks

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TRIP REPORT*

PLANNING FOR THE ESTABLISHMENT OF THE PROPOSED RODENT CONTROL PROJECT IN CHAD

April 23-May 12, 1989

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Unpublished Report

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SUMMARY

The purpose of this visit was to determine the logistic considerations and requirements for establishing a rodent control field station with a Denver Wildlife Research Center (DWRC) biologist working in Chad under U.S. Agency for International Development (USAID) Project funds. Discussions were held with personnel of AID/N'Djamena and Chad Ministry of Agriculture (MOA) personnel regarding a number of points related to personal (housing, vehicle recreation, consumables, etc.) and work-related (office, vehicle, contract logistical support services, etc.) needs.

A schedule was outlined for preliminary fieldwork to begin as soon as possible, involving one Chadian biologist on a USAID personnel services contract and two MOA Crop Protection agents. This fieldwork will provide necessary information on which to implement the Chad Project Scope of Work, which will probably begin in early 1990. A budget for this interim activity was sent from the USAID Representative Office to AID/Washington for approval.

Subsequent discussions on my return with USDA/OICD and AID/Washington officials about the proposal led to verbal approval for funds ($43,000) to be given to the AID/N'Djamena Office to support the interim activity. DWRC was receptive to this idea and agreed to provide a DWRC biologist to go to Chad in June (but changed to a later date at the request of Chad USAID Representative Office) to initiate the fieldwork.

PROJECT WORK-RELATED CONCERNS

The Director-General, Dr. Cherif Abdewahad, and Crop Protection Service Director, Dr. N'Garomillet, want the Project to begin immediately. They are prepared to move quickly when the DWRC biologist arrives and were extremely disappointed to hear that the Project Leader will not arrive before 1990. To avoid losing the strong motivation and enthusiasm which now exists in the Crop Protection Service, an interim proposal was prepared which provides for two Crop Protection personnel to collect field data in 1989 (see page 4, Proposed Field Activities for PSC Hiree).

AID/N'Djamena was informed by AID/Washington of funding in December 1988 and was expecting the arrival of a DWRC Project Leader to begin the Rodent Control Project. However, DWRC was not informed of formal approval until late spring 1989. Recruitment of a Project Leader is in progress.

Helpful arrangements were made while anticipating prompt establishment of the Project. For example, an additional ceiling position has been approved for this year to accommodate the DWRC biologist. Mr. Abdelwahid Yacoub, who has worked with DWRC biologists in Chad with enthusiasm and ability on prior years' activities, would be available as a Project Assistant as soon as the Project officially begins. He may not be available with a delayed start.

Office space is not available now in the MOA, but low cost modification on an existing building is possible. A small laboratory space near the proposed office is available, but animal quarters will have to be built on the Crop Protection grounds or existing structures will need to be modified. The MOA is enthusiastic about doing either.

HOUSING AND PERSONAL NEEDS

Ms. Hazel Kassebaum, the Community Liaison Officer, has recently revised the "Handbook for Expatriates Assigned to Work and Live in N'Djamena." Since the handbook is large, I have acquired a floppy disk for use in Denver (see Appendix A--Table of Contents). Also a short guide, "Visitors to the American Embassy, Chad" (copy on file in Denver) contains a lot of useful information for a new resident (see Appendix B).

Up to a dozen homes are available at any one time. Development Management Services (DMS), a contract firm which provides operational services for USAID staff, is prepared to have one ready after approval by the USAID Housing Committee soon after arriving or, if preferred, to have one ready upon arrival. These homes will require all basic furnishings and appliances, including a standby generator (if one is not already present) and step-down transformers, voltage regulators, and surge suppressors; voltage is 220, with 50 cycles.

Consumables which should be brought are given in the attached handbooks (Appendices A and B). Some items, which are not necessarily critical but locally scarce, deserve mentioning. They include black pepper, vanilla, any special sauce, feminine needs, baby food, Band-Aids®[1], medicines, brown sugar, juices, and cake flour for baking. The consumable allowance--2,500 lbs maximum--can be used immediately or delayed up to 1 year before ordering. Bleach (available locally), <u>not</u> iodine, is recommended on vegetables.

The American school has 25 children up through the ninth grade. Recreational clubs are plentiful for riding, flying, tennis, and swimming.

DMS, under a services contract, will maintain the house 24 hours a day. This includes almost everything except light bulbs and guards. For example, a plumbing problem at 0300 hours will, theoretically, receive immediate attention.

A personal vehicle should not be American-made. Parts and maintenance are not readily available. Peugeot, Renault, or Toyota are brands that are suitable for N'Djamena. Specifications of American or French versions of these vehicles are often different from those found in Chad. A Peugeot ordered from Nigeria is the most common vehicle in N'Djamena and easiest to maintain. It can be obtained in about 10 days after ordering from a dealer in N'Djamena. A few used cars are occasionally available for sale by departing diplomats. One person recommended ordering a French car through

[1] Reference to trade names does not imply endorsement by the U.S. Government.

France as the best way to get a personal car to Chad, but this opinion was not widespread.

In short, this post will not be as difficult to enjoy as many think. To really enjoy it, however, it is highly recommended that both spouses speak French.

AID/N'DJAMENA SERVICES AND SUPPORT

With an office to be built at the MOA, all that would be needed at the USAID Office would be occasional desk space and availability of the DMS support package--typing, xeroxing, travel office, dispatching, and telexing.

The USAID Office provides guards for the house. This is not in the DMS package at the moment.

Technical backstopping from the Agricultural Office and personal mail, including pouch items up to 2 lbs, will be available. Direct hire, U.S. Government employees, including USDA contractors with official or diplomatic passports, can ship items up to 40 lbs.

DMS CONTRACT SERVICES

The Project person assigned will function as a direct hire and, therefore, will be eligible for a full support package offered by DMS for USAID personnel. However, arrangements must be negotiated and approved by USAID. A full support package, which would include personal support, residential and office maintenance, and vehicle operations, would cost approximately $25,000 to $30,000 annually.

The Project vehicle support portion includes a driver and maintenance. It does not include out-of-town travel, which must be negotiated extra, above the standard $7,000 vehicle operation and maintenance package included in the full support package.

DMS does not provide a standby generator for the residence. This should be provided by the Project as a line item. A generator is essential due to frequent power outages, particularly during the hot, dry season. Purchase of this generator should be done with advice from DMS, which is familiar with local requirements.

Project funds will have to be used to provide basic furnishings and all major appliances.

DMS will assist in obtaining a 4-WD vehicle by recommending appropriate makes and/or models and handling the paperwork, clearances, etc. They will provide a driver and maintain the vehicle as part of their services package. DMS will also assist in obtaining other commodities to assure compatibility of these items to local conditions.

PROPOSED FIELD ACTIVITIES FOR PSC HIREE

Since the USAID Office and the MOA are eager to begin Project activities as soon as possible, I outlined some field activities that could be started now. Mr. Abdelwahid Yacoub was identified as being capable and interested to represent AID/N'Djamena in coordinating fieldwork with MOA. The proposal includes selecting up to three areas (with at least two sites at each area) of different agroclimatic character and monitoring rodent populations, susceptible crop stages, rainfall, and habitat changes to provide valuable information when the Project Leader arrives.

The purpose for monitoring rodent populations is to determine when reproductive and population peaks occur in different agroclimatic zones. This information is vital in order to develop a strategy for control that anticipates proper timing. A monitoring and hence forecasting strategy will reduce cost, increase efficiency and safety, and provide confidence for recommending procedures for rodent control in specific areas of Chad.

Areas selected should be "typical" in terms of soil type, adjacent crops or habitat, and agronomic practices, and should include priority crops (by MOA ranking) that are known to be chronically affected by rodent damage. The actual sites within each area should be chosen carefully so that monitoring tasks can be completed year-round. Priority crops must be present for at least a portion of the year, and fallow periods should be included if they are a normal part of the cropping pattern. Sites should be about 1 ha. Detailed data from trapping, monitoring crop stages, counting burrows, and assessing damage will be collected from within, and general observations will be made outside, these 1-ha sites. Farmer cooperation will be helpful for planning tasks and obtaining farm input/output information, such as use of fertilizer, irrigation, or herbicide and amount of harvest or yield. Any rodent control trial or farmer rodent control should not be done within 200 m (meters) of this 1-ha study plot. An outline detailing the specific activities of this initial monitoring effort follows. Some of the practical and logistical aspects of this initial monitoring effort will be looked into during the September-October TDY's being implemented by Mr. Keith LaVoie and Dr. John Wilson, Research Director, Centre for Population Management, Queensland University of Technology, Australia, who is currently on sabbatical at DWRC.

Mapping the Site

Draw a rough approximation of the 1-ha study site and surrounding habitat up to 200 m away. Identify crop stages as specifically as possible (i.e., 45 days after seeding, vegetative stage), and describe uncultivated areas with descriptions like: mean height, density (thick, sparse), and dominant vegetation (grasses, bush, tree). Do this during each bimonthly visit, noting any significant changes (i.e., burning, cutting, flooding). Rodents under stress will move a long way.

Counting Active Rodent Burrows

Within the 1-ha study area, count all rodent burrow openings and plug or cover with dirt. The next day, count all burrow openings. Record each number--total burrow openings covered and active burrow openings observed.

Collecting Rainfall Data

During each bimonthly visit, obtain rainfall amounts for the previous 2 months from the nearest reliable weather station. Preferably, this should be daily, but weekly or monthly totals are acceptable. Be sure to indicate the units of measurement (mm, cm, in).

Trapping Rodents

Using 30 rat-size and 20 mouse-size snap traps, evenly distribute 50 traps over the 1-ha study site. This is most easily done by using two or more imaginary lines or transects, along which one or more snap traps are placed every given distance (i.e., 10 m). Whatever arrangement is used, the same arrangement must be repeated for each bimonthly trapping. I recommend using 30 evenly distributed points. At 20 of the 30 points, place both a rat and a mouse snap trap, while at the remaining 10 points, place a rat trap.

Use the same kind of bait on the trap triggers year-round. Good choices include small cubes of coconut or a small amount of peanut butter (perhaps mixed with rolled oats). Both baits adhere well to the trap trigger, require small amounts, and would be available year-round.

Set traps out in late afternoon; check and reset traps early the next morning. For each trap, record whether sprung, unsprung, or with an animal. Trap for 2 consecutive nights.

SUGGESTED DATA SHEET FORMAT

Trap						Wt.		Length (mm)				Testes	
No.	Typ	Spr	Uns	Ani	Specie	(gms)	Sex	To	T	E	Hf	Scr	LxW
1	R			X	*Praomys nat*	58	M	150	75	9	17	Yes	8x3
2	R			X	*Arvicanthis*	104	F	300	150	12	25		
3	M		X										
(etc.)													

Where,

Typ	= type of trap
R	= rat size
M	= mouse size
Spr	= sprung
Uns	= unsprung
Ani	= animal caught
Specie	= genus and specie's name, such as *Arvicanthis niloticus*
To	= total length, from nose to tail (not including tuft)
T	= tail length
E	= ear, from notch below canal to top of ear lobe
Hf	= hind foot, from ankle to tip of longest toe
Scr	= scrotal (testes outside the body)
LxW	= the length and width of the largest testicle

Any sign of female reproduction should be noted, such as enlarged or lactating mammae, enlarged uterus, or uterus with embryos present. For males, measure the size (greatest length and width) and/or weight of testicles, and whether the testicles are present in a scrotal sack outside the body or not.

If possible, stay overnight near the study site (1) to observe any trap vandalism and also (2) to reach the traps early in the morning. Prepare a study skin for any unusual rodent or rodent which you cannot positively identify.

If small, capped containers and 70% alcohol or 40% formaldehyde (formalin) are available, you may want to label each container by rat number, location, date, and species, and place the stomach in it to examine later for food habits. Otherwise, during necropsy, simply open the stomach and make some comments on the contents (as best as you can describe it), such as: color, texture, vegetation or animal (including insect) fragments and full, partially full, or empty.

Determining Damage Incidence

For each crop type within the study site, conduct a systematic damage assessment by examining randomly at least 0.1-1.0% of the estimated total individual plants at risk. Randomly pick rows, lines, or points that eliminate or reduce bias in selecting any one plant. Record only the incidence of damage--whether the plant is rat-damaged or not. The final tabulation should include totals to determine the following:

$$\frac{A}{B} \times 100 = \% \text{ incidence of rat damage}$$

Where,

A = Number of examined plants, rat-damaged
B = Total number of plants examined, both rat-damaged and not rat-damaged.

Summarizing and Graphing Data

For each study site (at least two in each area), tabulate all data, compute totals, means, and variances (S.E.), and enter the appropriate number on a graph to which additional bimonthly data can be added. Suggested items for graphing on a continuous basis are amount of rainfall, number of active burrows, total number of individuals of the most prevalent rodent species trapped, number of females, and percent females for each major pest species of those pregnant or lactating.

Reporting

Prepare a summary report every 2 months, including the above and other activities.

Equipment Required for Monitoring in Three Areas

Quantity	Item	Quantity	Item
200	Rat snap traps	100	Mouse snap traps
3	Pesola scale, 500 g	3	Dissecting kits
3	Pesola scale, 50 g	3 boxes	Borax
3 packages	Cotton	3 spools	Thread
3 boxes	Cornmeal	3 jars	Peanut butter
3 boxes	Oatmeal	200	Jars, screw cap with lids, about 50 ml
200	Labels		
3	Clip boards	3	Field notebooks
50	Trapping data forms	3	Metric rulers about 30 cm length
25	Graph paper, var.		
3 rolls	Survey tape	50	Damage assessment data forms
3	Calculators, solar powered, field use		

Proposed Budget for Rodent Monitoring Fieldwork

A draft budget prepared with Mr. Kurt Fuller, AID/N'Djamena, is attached as Appendix C.

ACKNOWLEDGMENTS AND CONTACTS

AID/N'Djamena

Mr. Bernard C. Wilder, AID Representative
Mr. Cary Kassebaum, Assistant Aid Representative
Ms. Jerry Ann Penno, Executive Officer
Mr. Kurt Fuller, Agricultural Development Officer
Mr. Bill Stringfellow, Project Leader, Organization for Rehabilitation through Training (O.R.T.)
Mr. Abdelwahid Yacoub, Former PSC Employee

DMS (Development Management Services)/N'Djamena

Mr. Kevin Guilde, Onsite Manager
Mr. Mark J. Heffernan, On Temporary Duty from Headquarters

Ministry of Agriculture/N'Djamena

Dr. Cherif Abdewahad, Director General
Dr. N'Garomillet, Director, Crop Protection Service

MOA/N'Gouri

Mr. Firmin Mansis, ORT Agronomist

AID/Abidjan

Dr. S. K. Reddy, Regional Agricultural Development Officer

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Appendix B	Guide for Visitors to the American Embassy, Chad (Table of Contents) Full text on file with IPRS, DWRC, Denver, Colorado
Appendix C	Submitted Budget for Proposed Fieldwork to Monitor Rodents
Appendix D	Outline for Rodent Monitoring Work

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<u>APPENDIX A</u>

HANDBOOK FOR EXPATRIATES ASSIGNED TO WORK AND LIVE IN N'DJAMENA

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APPENDIX B

GUIDE FOR VISITORS TO THE AMERICAN EMBASSY, CHAD

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Visitors

to the American Embassy CHAD

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REVISED AND UPDATED JAN 1989

APPENDIX C

SUBMITTED BUDGET FOR PROPOSED FIELDWORK TO MONITOR RODENTS

Administrative Assistance (Personal Services Contract)		
Salary		
One person, 12 months, $775/mo	$ 9,300	
DMS Contract Support		
24 weeks, $300/wk	7,200	
Per Diem for Fieldwork		
200 days (18 days/mo) at $64/day	12,800	
Transportation		
Vehicle, 4,000 km at $0.25/km	1,000	
Driver, 200 days at $20/day	4,000	
Air Travel (in-country), 3 trips ($300 each)	900	
Subtotal Project Cost		$35,200
Counterpart Support Costs		
Personnel		
Two Crop Protection Service Agents at $8.33/Day for 200 days	3,332	
Transportation		
Vehicle	2,500	
Air (in-country), two people, 3 trips	1,800	
Subtotal Counterpart Cost		7,632
Supplies and Equipment (Local)		168
Grand Total		$43,000

Notes:

Include a contingency of ±10 percent for each line item for efficient use of funds.

Above budget will provide for one PSC and two CPS agents with full support to conduct bimonthly field visits to three sites for monitoring rodent populations in agricultural crop habitats.

Coordinate approval of budget with AFR/TR/ANR and OFDA with DWRC.

APPENDIX D

OUTLINE FOR RODENT MONITORING WORK

	A (N'Gouri)	B (Bongor)	C (Abeche)
Area			
Site 1 (rainfed)	Millet	Groundnuts	?
Site 2 (irrig.)	Sorghum/veg.	Rice	?
Site 3 (optional)	?	?	?
Activities, initial			
Select 1-ha plots	September		
Activities, bimonthly			
Map site			
Record crop stages			
Count active burrows			
Collect rainfall data			
Snap trap 2 nights			
Determine damage incidence			
Summarize data and graph each area			
Prepare short bimonthly report on activities			

Note:

This draft outline has been modified by Keith LaVoie (DWRC biologist) and John Wilson (visiting scientist from Australia) who will initiate the fieldwork during a scheduled TDY in September.

TRIP REPORT*

Environmental Effects of Insecticides Used in Locust Control

SENEGAL

June 27-September 3, 1989

by

James O. Keith
Research Biologist

International Programs Research Section
Denver Wildlife Research Center
Science and Technology
Animal and Plant Health Inspection Service
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Unpublished Report

September 14, 1989

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Itinerary

June 27-28	Travel from Denver, Colorado, to Washington, D.C.
June 28-29	Travel to Senegal
June 30	Contact with USAID, Dakar, and travel to Richard Toll, Senegal
July 1-9	In Richard Toll
July 10-11	In Dakar
July 12-Aug 1	In Richard Toll
Aug 2-3	In Dakar
Aug 4-30	In Richard Toll
Aug 31-Sept 1	In Dakar
Sept 2-3	Travel to Denver, Colorado

OBJECTIVES

To conduct studies in Senegal on the impact on birds of the use of insecticides to control African migratory locusts.

BACKGROUND AND STUDY

On June 27, I traveled to Washington, D.C. to brief USAID staff on the objectives of environmental studies to be conducted cooperatively by FAO, the Netherlands, France, Great Britain, and the USA. I met with Africa Emergency Locust and Grasshopper Assistance Project (AELGA) staff the morning of June 28 during their weekly meeting to discuss locust conditions in Africa. I briefly outlined our study plans (Attachments 1 and 2). Later in the morning I met with Mr. Carroll Collier, Project Leader, USAID/Bureau of Science and Technology. In the afternoon I completed travel arrangements at OICD and the USDA Travel Office and left in the evening for Senegal, arriving the afternoon of June 29.

On June 30, I contacted Mr. James Bonner, Agricultural Development Officer, AID/Dakar. We discussed objectives of the cooperative research project and some security problems arising from tensions between Senegal and Mauritania along the Senegal River, the border between the two countries. I visited FAO offices in Dakar and left for Richard Toll in a project vehicle. I worked near Richard Toll until August 30, except for two brief visits to Dakar. The first trip, on July 10 and 11, was to assist with selecting and ordering supplies and equipment for establishing a field camp near Richard Toll. The second trip, on August 2 and 3, was to review facilities at the University of Dakar, to discuss ChE analytical methods with their toxicology staff, and to obtain assistance from DWRC/Denver in ordering equipment and supplies for cholinesterase (ChE) analyses of tissues from animals to be collected in study areas. ChE levels in birds will be analyzed at the University of Dakar.

At Richard Toll, Mr. Wim Mullié and I spent 5 days traveling through savannah habitat within 30 km of Richard Toll to select a general study area in which to locate study plots. We decided on an area of about 10 km x 12 km along a main dirt tract about 20 km southeast of Richard Toll. During the next 10 days, with help from Mr. Harold Van der Valk, we located five 2-km x 3-km plots in this study area; all plots are separated by at least 2 km from each other (Attachment 3). This job was made difficult by the lack of detailed maps of the area showing roads or other physical features. One plot will not be treated and will serve as a control. The other four will be treated, either with a high or low dose of fenitrothion or chlorpyrifos. Six transects, 1.0 km in length and 250 m apart, were established in each plot (Attachment 4). A circle of white paint was painted on trees each 100 m along transects. On July 24, bird counts were begun on transects. Mr. Wim Mullié and I both took counts on three transects in a plot each day, beginning at 7:00 a.m.. Counts on transects were for a duration of 50 minutes, with 5 minutes being spent in each 100-m segment. Birds seen were identified and their numbers tallied. Species identified on the study area are given in Attachment 5. Considerable time was spent in learning to identify these species by sight and by their calls.

Each week, counts were obtained on all five study plots. Counts were repeated for 5 weeks until August 26. As an example of results obtained, data for my counts on plots are shown for selected species in Attachment 6. These five pretreatment counts will later be compared with five posttreatment counts to evaluate treatment effects on bird abundance.

In addition to transect counts, counts were also taken in low-lying, heavily vegetated depression areas. These 0.1- to 1.0-ha areas are scattered throughout study plots and are rich microhabitats for birds. Counts were obtained at least twice in each of five depressions per plot to supplement transect counts.

Observations were made to determine which birds were breeding and their reproductive progress. As rains began in July and continued into August, vegetation development transformed the dry savannah into a verdant, productive area. Many resident birds responded by initiating reproduction. Thirty nest boxes were constructed and placed in plots to determine if they would be used. Nest boxes might be useful in future studies on reproductive success and growth rates of young relative to spray treatments and resultant changes in the insect biomass available to feed young.

Three species of birds were selected for study to determine food habits and cholinesterase levels in brains before and after treatments. At least 10 individuals of each species were collected in mist nets, dissected, and crops and brains removed. This collection will provide pretreatment information. Crop contents are preserved in alcohol, and brains are being stored in liquid nitrogen until analyses.

Twelve men from a village near our camp were selected as a team to help our staff search plots for bird mortality after treatments. Each plot will be searched the first and second day after it is treated. Searches will also be conducted on the control plot.

Treatment of plots with insecticides should begin in early September. I returned to Senegal September 13 to obtain posttreatment data from plots, to assist the study team in completing assessments of this year's studies, and to plan for future studies. Obvious treatment effects will be reported after September and October field work is completed. A complete report on this study will be prepared and distributed later after data have been compiled and samples have been analyzed for residues and cholinesterase levels.

CONCLUSIONS

Our study team includes ornithologists, an ichthyologist, an aquatic biologist, terrestrial entomologists, an expert in soil micro-organisms, toxicologists, ecologists, and a pesticide application specialist (Attachment 7). It has seldom been possible to have such diverse specialists work together in an experimental study. The extent of ecological and biological processes covered by the study team is extensive and results should provide a good basic assessment of the kinds of environmental effects that result from applications of fenitrothion and chlorpyrifos. Despite this expertise, this 3-month study will only indicate the nature of effects to be expected from the four treatments. Mortality of birds, if it occurs, may be a function of the particular ecological setting in which treatments were made. The composition, abundance, and behavior of species exposed and the productivity of treated habitats would be different in other areas and even in other seasons. In addition to mortality, the influence of spray treatments on food habits, immigration, and reproductive success may be suggested by this year's work, but such effects will not be thoroughly documented. Future studies will be needed and such research is now being planned.

REPORT OF THE WORKING GROUP

ON ENVIRONMENTAL SIDE-EFFECTS OF DESERT LOCUST CONTROL

FAO, Rome, 14 - 16 February 1989

PART I - SUMMARY OF DISCUSSIONS

1. Objectives of the Working Group

The Working Group was called as a follow-up to the "Meeting on Desert Locust Research: Defining Future Research Priorities" (Rome; 18-20 October 1988) which recommended the convening of a Working Group on environmental impact assessment.

It was decided by FAO/ECLO not to hold a general meeting on potential environmental impact of chemical locust control such as is being convened for other areas of locust research and development, but rather a working group with a specific task. Neither was it considered useful to elaborate the subject more than had already been done in several other fora, given the limited actual field data available on the subject. In addition, at the time the Working Group was called, a specific proposal for a pilot study had been put forward (Dept. of Toxicology, Wageningen Agricultural University for which the Government of the Netherlands has expressed interest to consider financial support).

The objective of the Working Group was therefore to discuss and further elaborate a pilot project to study side-effects of Desert Locust control. This should be done on the basis of the participants' personal experience in similar work and existing impact studies of locust control.

2. A list of participants is attached as Appendix II.

3. General Outline of the Project

The project under discussion was Phase I of a possible two-Phase project to study the environmental impact of chemical pesticide use in locust control.

Phase I: Pilot project of 5.5 months (of which three months in the field)

Phase II: Main project, up to three years. Detailed objectives are to be determined by the outcome of the pilot project and other existing field trials on impact of chemical locust control

Phase I of the project is to be carried out in the period June-October 1989 of which 3.5 months will be field-work. The proposed trial area is the Senegal River Delta in northern Senegal.

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4. General Discussion

i) Objectives of the study

The objectives of both the pilot study and the possible longer term follow-up project should be: to collect information on the environmental impact of chemical Desert Locust control needed to protect ecosystems from undesirable side effects; to provide National Plant Protection Services, donor countries and international organizations, in addition to data on pesticide efficacy, with data on environmental impact on which to base the choice of suitable pesticides; to develop guidelines for impact assessment in Desert Locust control.

ii) Undesirable side-effects were defined as all side-effects which last longer than one growing season, or all short-term effects on species or ecological functions which are considered unacceptable for specific well defined reasons (e.g. endangered or protected species, fisheries, pollinators of important crops).

iii) Species and ecological functions to be studied

Since the pilot project covers only a limited time span, the study has to focus on a limited number of species or ecological functions. The project will concentrate therefore on the following:

- production function of aquatic habitats:

  groups to be studied:
  - aquatic invertebrates
  - fish

- production or regulation function of supra-terrestrial habitats:

  groups to be studied:
  - arthropods (concentrate on pollinators, potential parasites or predators of insect pests)
  - vertebrates (insectivorous birds)

- specific groups of key organisms or protected/endangered species or important species:

  groups to be studied:
  - e.g. termites (soil structure)
  - certain bird species.

It was stressed that whenever possible the functional links between the effects on different groups of organisms should be studied. As an example it was suggested that major effects on birds may not be caused through acute poisoning by the pesticides. However, temporary food depletion by mortality of arthropods could cause birds to emigrate from the area or result in a reduction in breeding success.

iv) Methodology

The following conditions were considered of primary importance in choosing the methods to be used in the study:

- sufficient flexibility to allow for variable field situations;

- concentrate on identifiable species unless a taxonomic group of a higher order has a specific functional importance. If not, above species level assessments have little value;

- the use of community parameters (e.g. "diversity") should be avoided given its generally little relevance in impact assessment;

- since it is often not possible to use Analysis Of Variance (ANOVA) type experimental lay-outs (i.e. low number of replicates feasible) the use of Before-After Treatment Control analysis (BACI, time series analysis) is preferred. However, to obtain any statistically analysable results, long pretreatment monitoring in both control and to-be-treated plots are then required;

- for a valid conclusion about the causal relationship between a pesticide application and an observed effect, often at least two of the following conditions should be met for each data set:

  * coincidence of treatment and effect;
  * dose-response relationship;
  * observed recovery of effect;
  * additional information on an observed effect from biochemical or exposure parameters;
  * observations of effects in individual organisms (e.g. bioassay, carcasses);

- concentrate on a few chemicals on sufficiently large and/or replicated plots rather than many chemicals which are insufficiently investigated.

It was noted that in some of the previous studies on environmental impact of locust control several of these conditions were not met. This made evaluation of the results relatively difficult and in some cases impossible.

5. Study Area

The study area of the pilot project will be in northern Senegal, in the area between semi-arid grassland and the wetlands of the Senegal River delta. The region is outside the recession area of the Desert Locust but it was extensively invaded in 1988. It is ecologically very vulnerable to pesticides. Local laboratory facilities are available in the area, and logistics relatively easy. In the area a gradient exists which stretches from the wetland habitats in the centre of the delta and the river valley, to an agricultural belt on the slightly higher ground, to semi-arid steppe/grassland on the higher ground. In a large part of the delta/valley this gradient is fairly narrow (several kilometres). Although this increases the variability in habitats (and thus reduces the chance of finding homogeneous trial plots) it also allows effects in several habitats to be studied by the same team.

It was recognized that any follow-up studies should include the ecologically relatively isolated locust habitats such as wadis or oases which may show specific responses to pesticide application, quite different from the ecosystems in the areas studied so far.

6. Pesticides

The following three pesticides were chosen for the study:

1. fenitrothion at 500 g a.i./ha ("standard" pesticide);
2. chlorpyrifos at 240 g a.i./ha (widely used "new" locust pesticide, used on large scale in last campaign);
3. diflubenzuron at ca. 40 g a.i./ha (potential residual pesticide for hopper control).

All will be sprayed at the above recommended rates and at double this rate to simulate overapplication. Since diflubenzuron is an Insect Growth Regulator with a very low avian and mammalian toxicity, its effects will only be assessed on terrestrial invertebrates and, if possible, on aquatic invertebrates.

Several other pesticides were discussed, but the pilot study was considered of a too limited nature to cover more than the above three chemicals in a sufficiently through manner.

The pesticides will be applied by air on the large spray blocks while possibly some small scale assessments can be done using ground equipment (e.g. termites, pond studies).

7. Plot Size and Trial Lay-out

The minimum plot size for the ornithological studies was considered to be approx. 12 km^2. Even with these blocks census counts may only show effects in territorial birds. It was considered feasible that these blocks would include the trial plots for the terrestrial invertebrate study as well. This would also give an opportunity to relate effects in the two groups of organisms. Isolated ponds which fall within the plots can be used for aquatic monitoring. It was considered unwise to cover the whole delta ecosystem gradient within the same plot since this would result in too large a variation in habitats. Therefore, smaller blocks in the wetland area may need to be sprayed for additional aquatic monitoring. This is to be decided by the team when on the spot.

The basic trial lay-out of the pilot study therefore consists of six blocks of ca. 12 km^2 each. Three pesticides will be applied at two dose rates. Depending on local circumstances, additional smaller plots may need to be sprayed.

The pesticide applications will be carried out regardless of the presence of Desert Locusts in the area. The study and related necessary logistics are too complicated to be shifted around according to locust availability. Most of the side-effects assessment can however be done without locusts on the spot as long as the ecological conditions are suitable for Desert Locust invasion/breeding. It was noted that without locusts being present, investigating the effects of (mainly) birds scavenging on sprayed locusts cannot be studied. However, if in not too distant areas actual Desert Locust control is carried out, the team should be able to assess its acute effects on short notice.

8. Institutions involved in the study

The Netherlands Government is prepared to finance a large part of the study including three Dutch experts (Department of Toxicology, Wageningen Agricultural University), major equipment and supplies, and operating expenses. Given the lack of experience of the above mentioned Research Group with field assessment of impact on fish populations, the UK Government has been requested by FAO to fund a fish toxicologist plus expenses from Overseas Development Natural Resources Institute (ODNRI) for the study. The Meeting agreed that the ornithological part of the study would require more specialised input than foreseen. Therefore the US Government will be requested to finance a vertebrate toxicologist plus expenses from Denver Wildlife Research Center (DWRC) for the duration of the study.

Both Wageningen Agricultural University (Department of Toxicology), ODNRI and DWRC have extensive field experience with pesticide impact studies in Africa.

The "Institut des Sciences de l'Environnement" (ISE) of Dakar University will be asked to act as the main scientific counterpart. Given its specific experience it will be requested to cover the chemical monitoring part of the study. In addition, the possibility of having one or two of the institute's students participate in the study will be investigated.

FAO will be responsible for the overall coordination of the study, ensure liaison with the Government and regional organizations, and purchase equipment. Further FAO will nominate a consultant to be attached to the field-part of the study with a background in environmental toxicology and an application specialist to assist in the pesticide applications.

The Senegalese Plant Protection Department (DPV) will be requested to assist with in-country coordination and to assist in transport and logistics. Furthermore, DPV experts will be asked to participate in specific parts of the trials.

9. Follow-up actions

i) Agreement of UK and USA to fund the proposed experts (by the end of March);

ii) agreement of Senegalese Government to implement the study (April);

iii) agreement of ISE scientific cooperation (April);

iv) start purchasing equipment (April).

Both (ii) and (iii) will be discussed during an FAO mission to Senegal in the second decade of April.

10. Part II of this report covers the project description and gives further details on specific methodology proposed for the study.

WORKING GROUP ON ENVIRONMENTAL SIDE-EFFECTS OF DESERT LOCUST CONTROL

FAO, ROME, 14 - 16 FEBRUARY 1989

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FAO

Mr. Phil Symmons
Consultant
AGP

Mr. Harold Van der Valk
Consultant
AGP

Ecological Effects of Some Insecticides Used for Locust Control in Africa

Cooperative Investigations to be conducted by:

The Netherlands
United Kingdom
USAID and FAO

Scope of Work for Bird Studies

Prepared by
James O. Keith, Biologist
International Programs Research Section
Denver Wildlife Research Center
USDA/APHIS/S&T

April 21, 1989

INTRODUCTION

Fenitrothion and chlorpyrifos are insecticides widely used for Africa for control of migratory locusts. The impact of these chemicals on African environments has not been adequately assessed. Knowledge is needed of the ecological consequences of their use in natural habitats and their effects on wildlife. In 1989, an international team of scientists will begin studies of these relationships on areas experimentally treated along the Senegal River in northern Senegal. Ecotoxicologists from The Netherlands, United Kingdom, FAO, and the United States will cooperate for evaluating effects on the abundance and diversity of invertebrate and vertebrate organisms in treated areas and the resulting ecological disruptions that occur.

The Africa Bureau, USAID, will support studies on birds by the Denver Wildlife Research Center (DWRC) in these cooperative investigations. Objectives of the DWRC work, methods to be used, and projected costs are presented here for review.

OBJECTIVES

To determine effects of experimental fenitrothion and chlorpyrifos applications on:

1. abundance of birds on study plots,

2. foods of birds on study plots, and

3. mortality of birds on study plots.

METHODS

Effects on birds will be measured on five 12 km^2 plots. Two will be treated with fenetrothion, two with chlorpyrifos, while the fifth plot will not be treated.

Bird abundance will be measured on treated and untreated plots before and after spraying of insecticides to determine if changes occur due to treatments. Five, one-hour counts on each of five transects per plot will be made during 3 weeks just prior to treatments. Counts will be repeated after insecticides are applied. Results will show if important changes in bird numbers and species diversity occur.

Insectivorous birds will be captured in mist nets away from plots before spraying and their crops removed for food habits analyses. After insecticide applications, birds will be caught on experimental plots so that their foods at that time can be documented. Changes in food habits found probably will be related to decreases in certain invertebrates. Mortality and population decimation of invertebrates will be thoroughly investigated by other team members. Results will permit an assessment of treatment effects on energy available to birds.

Each day during the first 3 days after spraying, all five study plots will be systematically searched for carcasses of vertebrates and invertebrates killed by insecticides. All carcasses will be collected and preserved for residue analyses. Chemical analyses will be made later at the Department of Toxicology, Wageningen University, The Netherlands.

If changes in bird numbers are found after teatments, food habit information and bird mortality may explain why their abundance decreased.

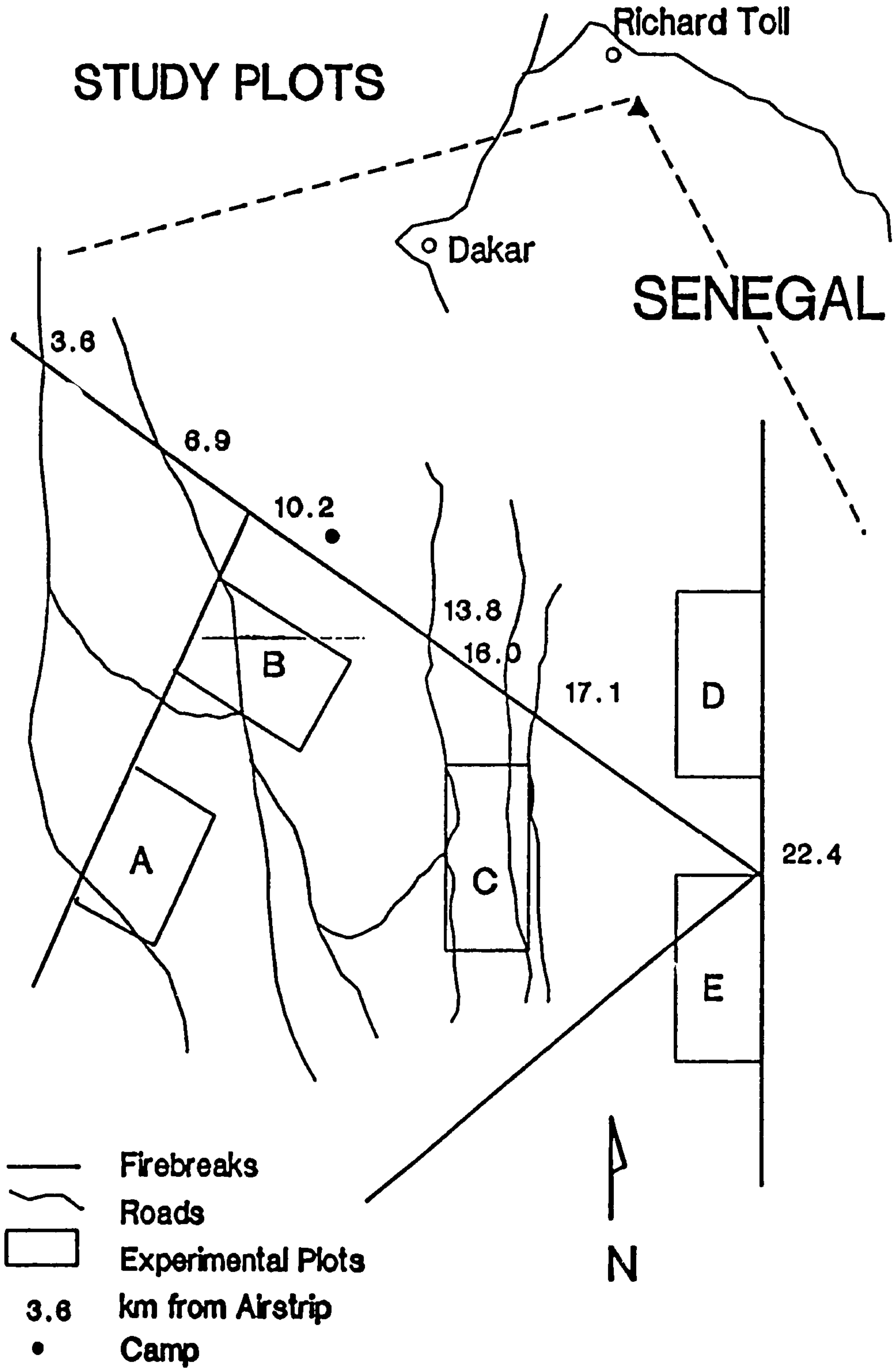
SCHEDULE

The DWRC ornithologist will join the international team in Senegal in late June to help select study plots and establish transects. Working from a field camp established by The Netherlands, pretreatment data will be collected in July, plots will be treated around the first of August, and posttreatment data will be gathered during 4 weeks thereafter.

COSTS

Costs of this research will consist of salary for a DWRC ornithologist, his travel to and from Senegal, rental of a 4-wheel drive vehicle for field work, per diem, and miscellaneous supplies and services. Salary costs include time spent in the field collecting data, time in the laboratory analyzing bird food habits, and time spent in preparation of reports.

The Netherlands will also have an ornithologist on the team. He will assist with bird counts and conduct other evaluations, including the influence of treatments on nesting birds, bird feeding behavior, and mortality in wetlands treated for aquatic studies.


STUDY PLOTS
Richard Toll
Dakar
SENEGAL
3.6
6.9
10.2
13.8
16.0
17.1
22.4
A
B
C
D
E
N
Firebreaks
Roads
Experimental Plots
3.6 km from Airstrip
Camp

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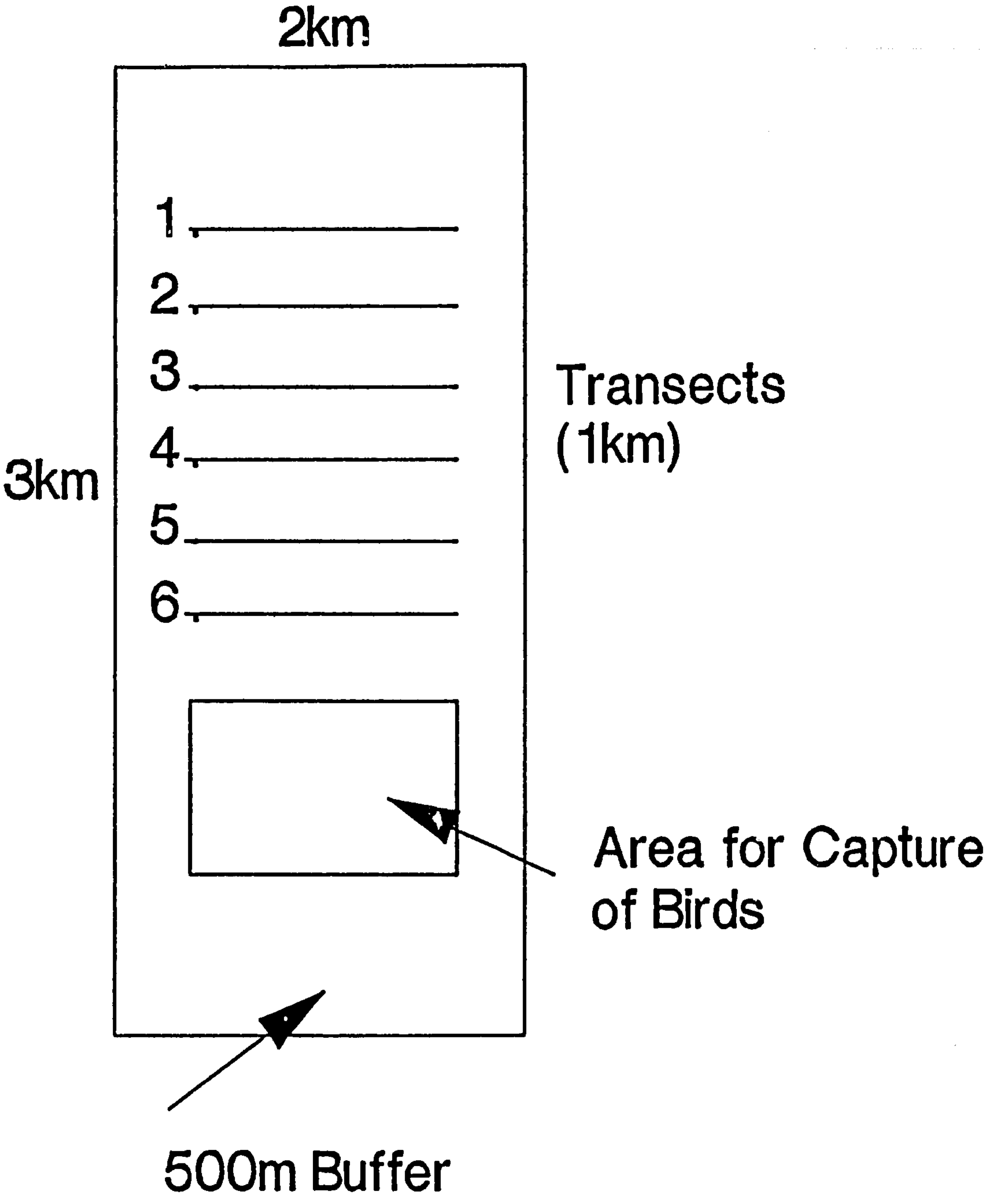
LAYOUT OF STUDY PLOTS



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Latin name	Weight (gram)	English vernacular name
Torgos tracheliotus		Lappet-faced Vulture
yps rupellii		Ruppell's Vulture
yps bengalensis		White-backed Vulture
ecrosyrtes monachus		Hooded Vulture
ircaetus beaudouni		Beaudouin's Harrier Eagle
quila rapax	1720	Tawny Eagle
elierax metabates		Dark Chanting Goshawk
alco biarmicus		Lanner Falcon
alco chiquera		Red-necked Falcon
rancolinus bicalcaratus		Double-spurred Francolin
umida meleagris		Grey-breasted Helmet Guinea-fowl
oturnix delegorguei		Harlequin Quail
rdeotis arabs		Arabian Bustard
upodotis senegalensis		Senegal Bustard
upodotis melanogaster		Black-bellied Bustard
eotis denhami		Denham's Bustard
ophotis ruficrista		Crested Bustard
urhinus senegalensis		Senegal Thick-knee
edicnemus capensis	400	Spotted Thick-knee
anellus tectus	145	Black-headed Plover
ursorius cursor		Cream-coloured Courser
ursorius temminckii	61	Temminck's Courser
ursorius chalcopterus	190	Bronze-winged Courser
terocles exustus	210	Chestnut-bellied Sandgrouse
urnix sylvatica		Button Quail
rtyxelos meiffrenii	18	Quail-plover
ena capensis	35	Namaqua Dove
treptopelia senegalensis	100	Laughing Dove
treptopelia roseogrisea	140	Rose-grey Dove
treptopelia vinacea	120	Vinaceous Dove
urtur abyssinica		Black-billed Wood Dove
treptopelia decipiens		Mourning Dove
oicephalus senegalus	130	Senegal Parrot
sittacula krameri	150	Ring-necked Parakeet
lamator glandarius	200	Great Spotted Cuckoo
lamator levaillanti		Levaillant's Cuckoo
uculus caprius	27	Didric Cuckoo
uculus gularis	100	West-African Cuckoo
laucidium perlatum		Pearl-spotted Owlet
tus leucotis		White-faced Owl
aprimulgus inornatus		Plain Nightjar
acrodipteryx longipennis		Standard-wing Nightjar
olius macrourus	50	Blue-naped Mousebird
alcyon leucocephala		Grey-headed Kingfisher
alcyon senegalensis		Senegal Kingfisher
erops albicollis	25	White-throated Bee-eater
erops orientalis		Little Green Bee-eater
oracias abyssinicus	140	Abyssinian Roller
Coracias naevius	140	Rufous-crowned Roller
Upupa senegalensis	60	Hoopoe
Phoeniculus purpureus	58	Senegal Wood Hoopoe
Phoeniculus aterrimus	27	Lesser Wood Hoopoe
Tockus nasutus	160	Grey Hornbill
Tockus erythrorhynchus	160	Red-beaked Hornbill
Bucorvus abyssinicus		Ground Hornbill
Lybius vieilloti	34	Vieillot's Barbet
Campethera punctuligera		Fine-spotted Woodpecker
Mesopicos goertae	50	Grey Woodpecker
Mirafra javanica	25	Singing Bush Lark
Eremopterix leucotis	13	Chestnut-backed Finch Lark
Eremopterix nigricans		White-fronted Finch Lark
Tchagra senegala	50	Black-crowned Tchagra
Laniarus barbarus	50	Barbary Shrike
Nilaus afer		Brubru Shrike
Lanius excubitor	65	Great Grey Shrike
Lanius senator	38	Woodchat Shrike
Oriolus auratus		African Golden Oriole
Lamprocolius chalybaeus	100	Blue-eared Glossy Starling
Spreo pulcher	65	Chestnut-bellied Starling
Buphagus africanus	65	Yellow-billed Oxpecker
Pycnonotus barbatus	37	Bulbul
Cercotrichas podobe	24	Black Bush Robin
Cercotrichas galactotes		Rufous Bush Robin
Camaroptera brachyura	9	Grey-backed Camaroptera
Cisticola aridula	7	Desert Fantail Warbler
Cisticola juncidis		Fantail Warbler
Cisticola sp.		unidentified Cisticola
Eremomela icteropygialis	6	Grey-backed Eremomela
Eremomela pusilla		Green-backed Eremomela
Spiloptila clamans	8	Cricket Warbler
Sylvietta brachyura		Crombec
Remiz punctifrons		Sudan Penduline Tit
Anthreptes platura		Pygmy long-tailed Sunbird
Nectarinia pulchella	7	Long-tailed Beautiful Sunbird
Amadina fasciata		Cut-throat
Bubalornis albirostris	64	Buffalo Weaver
Petronia xanthosterna		Yellow-spotted Petronia
Passer griseus	24	Grey-headed Sparrow
Passer luteus	13	Golden Sparrow
Passer luteus (flying)	13	Golden Sparrow (fly over trans.)
Ploceus vitellinus	19	Vitelline masked Weaver
Quelea quelea	15	Quelea
Sporopipes frontalis		Scaly-fronted Weaver
Pytilia melba		Melba Finch
Lonchura malabarica	12	Silverbill
		Swift sp.
Plectropterus gambensis		Spur-winged Goose
		Falcon sp.
		bird sp.
Streptopelia sp.		cf. Turtle Dove
		cf. Booted Eagle
		Warbler sp.

Attachment 6

NUMBERS OF MOST COMMON SPECIES

Totals for Pretreatment Counts on Keith's Three Transects
During Five Counts--July 24-August 26, 1989

Species	A	B	C	D	E	Total
Black-headed Plover	12	-	-	43	-	55
Sandgrouse	61	14	-	4	13	92
Namaqua Dove	57	43	70	32	208	410
Laughing Dove	27	6	30	35	79	177
Rose-grey Dove	142	52	112	47	572	925
Vinaceous Dove	31	8	12	12	70	133
Parakeet	17	26	8	5	3	59
Bee Eater	6	8	16	19	35	84
Abyssinian Roller	65	26	41	58	71	261
Red-beaked Hornbill	21	4	3	1	2	31
Grey Hornbill	4	4	3	2	-	13
Singing Bush Lark	240	419	588	654	397	2,298
Finch Lark	51	10	19	81	29	190
Woodchat Shrike	11	7	20	21	13	72
Blue-eared Glossy Starling	20	18	18	15	9	80
Chestnut-bellied Starling	42	26	43	19	58	188
Black Bush Robin	8	-	11	2	9	30
Camaroptera Warbler	9	3	5	8	5	30
Fantail Warbler	41	16	14	24	3	98
Long-tailed Beautiful Sunbird	13	-	8	12	5	38
Buffalo Weaver	279	275	234	261	522	1,571
Golden Sparrow	4,332	7,586	6,691	3,747	4,060	26,416
Swifts (all species)	624	139	421	47	94	1,325
						34,576

[C] Control plot   [ ] Plots with unusual highs for species

Liste des participants au Projet LOCUSTOX (ECLO/SEN/003/NET)

(par ordre alphabetique)

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Keith BANISTER	Ichthyologue (Grande Bretagne)
Mounirou CISS	Toxicologue, LCAT/ISE, Univ. de Dakar
Dick COURSHEE	Spécialiste Applications, ECLO, FAO, Rome
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TRIP REPORT*

Environmental Effects of Insecticides Used in Locust Control**

S E N E G A L

September 11-October 13, 1989

by

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** Details of this cooperative international research program and the accomplishments of earlier fieldwork in July and August are presented in a trip report dated September 14, 1989, available from the International Programs Research Section, Denver Wildlife Research Center.

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Itinerary

September 11-12	Travel from Denver, Colorado, to Dakar, Senegal
September 13	Travel from Dakar to Richard Toll, Senegal
September 14 - October 7	In Richard Toll
October 8	Travel from Richard Toll to Dakar
October 9-10	In Dakar
October 11-13	Travel from Dakar, Senegal, to Denver, Colorado

OBJECTIVE

To complete studies in Senegal of the impact on birds of insecticides used to control African migratory locusts and grasshoppers.

ACCOMPLISHMENTS

Insecticides applied for locust control have not been evaluated for ecological and nontarget effects under the conditions of their use in Africa. As locust control is continental in scope and large areas and amounts of insecticides are involved, environmental effects of treatments need to be assessed. Such research was initiated in Senegal during June, July, and August 1989 by an international team of scientists with expertise in diverse aspects of aquatic and terrestrial biology. Pretreatment data were obtained on experimental plots prior to treatments; insecticides were applied to plots in early September. Background information and details of pretreatment activities are available in an earlier trip report--SENEGAL, June 27-September 3, 1989--available from the Denver Wildlife Research Center.

In July and August, pretreatment information was obtained on the kinds and numbers of birds occurring on the five study plots. Five weekly counts on six transects (Attachment 2) were taken in each plot. In addition, golden sparrows, buffalo weavers, and singing bush larks were collected to determine foods they were eating and normal cholinesterase (ChE) levels in their brains. It was anticipated that both food habits and ChE levels of birds would be affected by insecticide treatments.

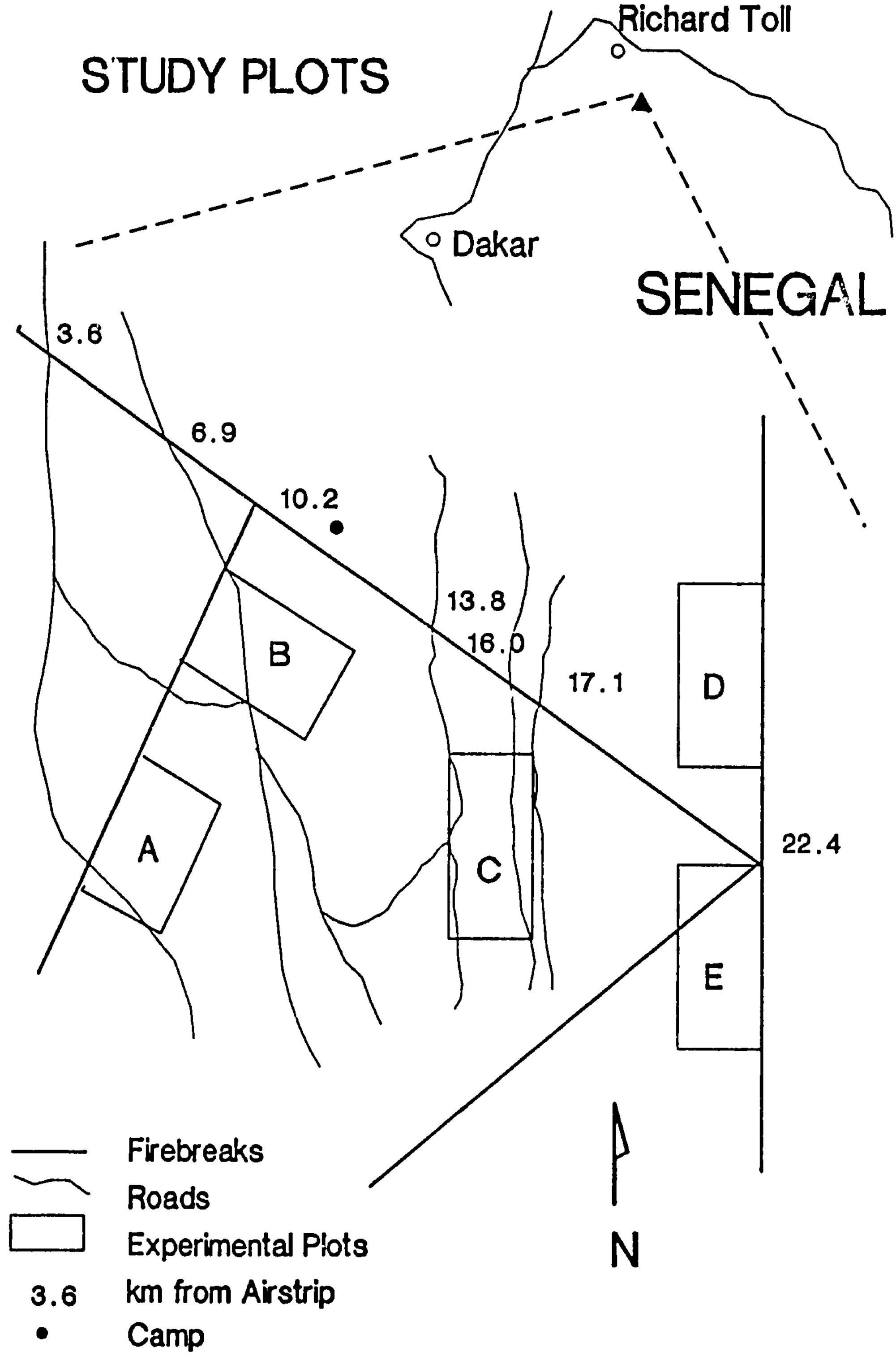
Insecticides were applied to experimental plots between September 5-11. Two plots (see Attachment 1) were treated with fenitrothion (A, at 500 g, and B, at 1,000 g/ha) and two were treated with chlorpyrifos (D, at 240 g, and E, at 480 g/ha). Plot C was not treated and served as a control. A 12- to 14-person search team walked through each plot twice, once at 24 hours and again at 48 hours after treatments. The fenitrothion (1,000 g/ha) plot also was searched at 3 and 6 days posttreatment. Searchers walked 20 m apart and covered a swath about 250-m x 2-km during each search. The area searched was about 25% of the central 1,000 x 2,000-m study area of each plot (see Attachment 2). A few dead and debilitated birds were found (Attachment 3).

Bird counts were resumed on September 12. The first count on each plot was made about 1 week after it was treated. Four weekly counts were taken on each of the treated and control plots. Considerable changes occurred in bird abundance on plots due to normal movements of birds between late July and early October. Numbers of golden sparrows, which were the most abundant birds on plots in July, decreased dramatically during August and September. Buffalo weaver numbers also decreased, largely before spray applications. Following treatments, numbers of singing bush larks decreased on all plots, including the control plot, as young birds fledged and larks left the study area. Other species, such as the woodchat shrike, gradually increased on all plots during August and September.

Changes in the abundance of other species appeared related to treatments (Attachment 4). Thorough compilation and analysis will be required of all data to determine which changes were real and which were related to treatments. Preliminary compilations of bird counts obtained by Dr. Keith suggest that the total number of individuals of the abundant species residing on plots were affected (comparing the last pretreatment count with the average of the four posttreatment counts). Totals of these collective species showed a reduction of about 45% on plots treated with 1,000 g/ha of fenitrothion and 480 g/ha of chlorpyrifos. Reductions in total bird numbers ranged from 17-32% on other plots, including the control plot. Reductions in bird abundance probably resulted from both normal movements and those in response to reduced food supplies following decimation of invertebrate biomass by the insecticides applied to plots.

Posttreatment collections of live birds were made during September to obtain gizzards for food habits analyses and brains for ChE determinations. Sampling was done for some species collected pretreatment, for species killed or debilitated by treatments, and for other species that were subjected to exposure but remained abundant on treated plots. Identification of insects found in stomachs and traps is continuing in order to document changes in foods eaten by birds and in invertebrate biomass after treatments. ChE analyses are being conducted at the University of Dakar and should be completed in November.

After bird count data are analyzed, food habits are determined, and ChE analyses are completed, a comprehensive report of results will be prepared. Our report will be included with those of other scientists to give a broad consideration of the ecological ramifications of fenitrothion and chlorpyrifos used to control locusts and grasshoppers in the specific ecosystems studied in northern Senegal. Results cannot be used to predict the consequences of such uses in other areas under different ecological conditions. Additional studies and evaluations will be required in other areas before questions about the environmental costs of locust and grasshopper control throughout Africa can be resolved.


STUDY PLOTS
Richard Toll
Dakar
SENEGAL
3.6
6.9
10.2
13.8
16.0
17.1
22.4
A
B
C
D
E
N
Firebreaks
Roads
Experimental Plots
3.6 km from Airstrip
Camp

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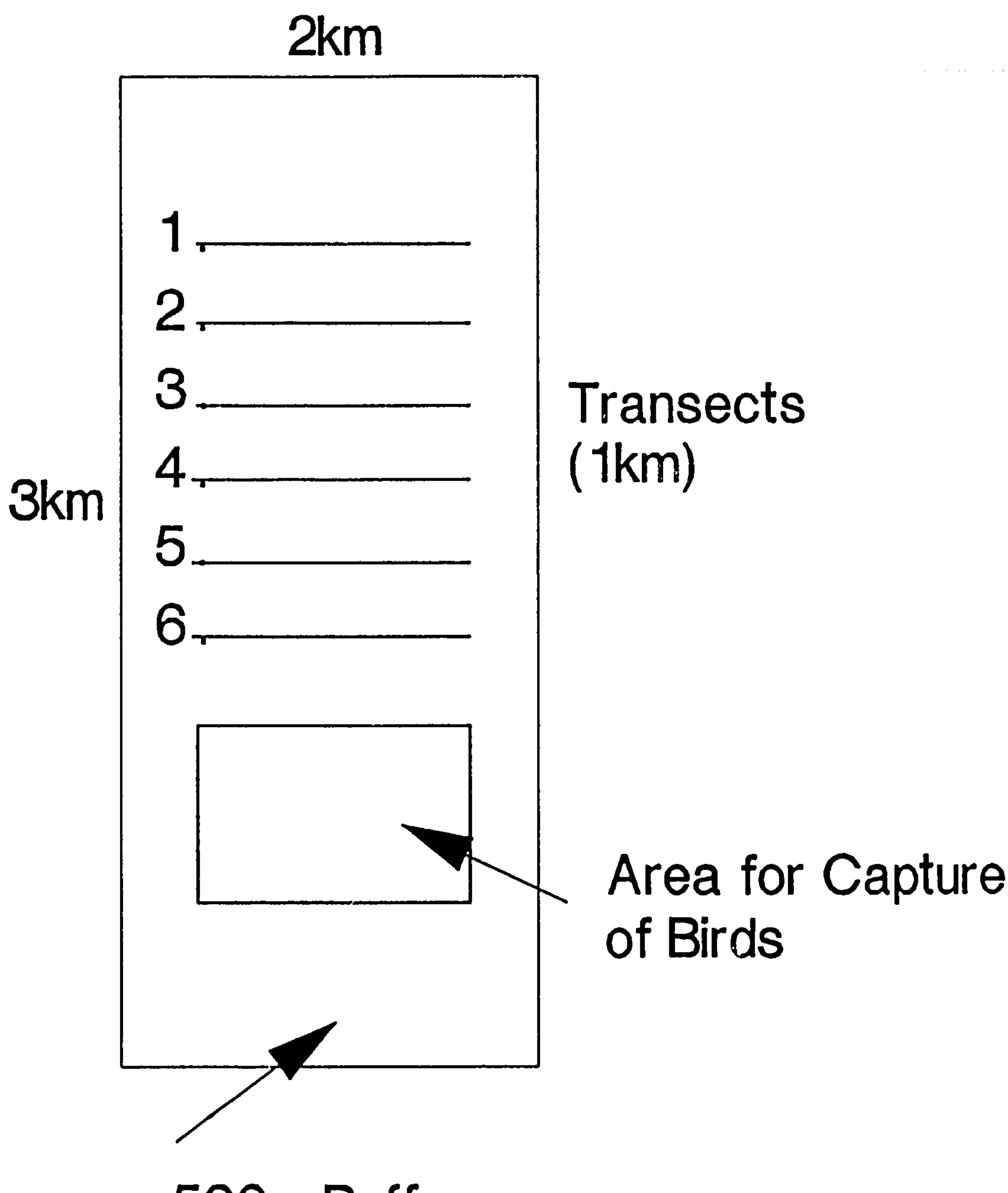
LAYOUT OF STUDY PLOTS



Dead (D) and Debilitated (d) Birds Found on Plots[a]

Species	Plot treatments[b]			
	F-500	F-1,000	C-240	C-480
Button Quail	-	2(d)	1(d)	-
White-throated Bee-Eater	-	-	-	1(d)
Abyssinian Roller	1(d)	1(d)	-	3(D)
Hoopoe	1(D)	2(d)	-	-
Singing Bush Lark	1(D)	2(D)	-	1(D)
Tree Pipit	-	1(d)	-	-
Woodchat Shrike	-	2(d)	-	-
Cricket Warbler	-	1(d)	-	-

[a] Fledglings of the long-tailed beautiful sunbird (2), buffalo weaver (1), singing bush lark (28), rose-grey dove (1), and Tchagra (1) were captured during searches. It was not clear if these birds were debilitated or simply flightless. ChE levels will be analyzed in dove, lark, and weaver brains. No dead or debilitated birds were found on Plot C (control).

[b] Treatments were fenitrothion at 500 g/ha (F-500) and 1,000 g/ha (F-1,000); chlorpyrifos at 240 g/ha (C-240) and 480 g/ha (C-480).

Partial Compilation of the Most Common Bird Species Counted on Study Plots Before (Last Pretreatment Count) and After (Average of the Four Posttreatment Counts) Spraying[a]

Species	Plots and Periods									
	F-500		F-1,000		Control		C-240		C-480	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Namaqua Dove	3	7	9	2	14	5	3	7	15	11
Laughing Dove	12	8	3	1	7	4	4	3	8	7
Rose-grey Dove	21	12	2	9	10	29	9	14	171	27
Vinaceous Dove	7	10	1	2	2	6	3	7	26	13
Blue-naped Mousebird	-	4	-	-	2	3	5	9	9	12
White-throated Bee-eater	-	5	1	6	2	16	6	7	6	10
Abyssinian Roller	17	7	1	13	10	23	22	20	13	22
Singing Bush Lark	69	10	74	20	123	30	93	70	84	29
Chestnut-backed Finch Lark	-	-	3	0.5	4	1	31	31	-	2
Woodchat Shrike	4	18	6	8	11	10	11	9	5	11
Blue-eared Glossy Starling	3	3	3	0.3	5	3	4	4	4	0.4
Chestnut-bellied Starling	12	9	7	5	12	13	4	6	15	11
Black Bush Robin	5	5	-	0.3	1	3	1	4	2	2
Fantail Warbler	12	10	4	4	5	1	1	1	1	0.3
Long-tailed Beautiful Sunbird	4	4	-	-	3	0.5	2	4	2	2
Buffalo Weaver	22	18	49	18	50	47	54	13	149	108
Golden Sparrow	491	166	293	98	841	92	555	103	263	177
Totals (except sparrows)	191	130	163	89	261	194	253	209	510	268
% Change	-32		-45		-26		-17		-47	

[a] Numbers are for counts on only three of the six transects on each plot.