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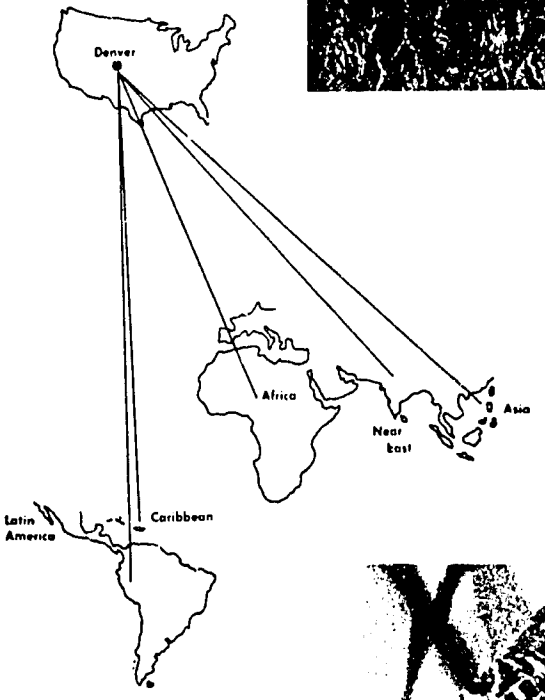
# VERTEBRATE DAMAGE CONTROL RESEARCH IN AGRICULTURE

## ANNUAL REPORT FY-90/91



Denver Wildlife Research Center
Animal and Plant Health Inspection Service
U.S. Department of Agriculture

Agency for International Development

# ANNUAL PROGRESS REPORT

**Fiscal Years 1990 and 1991**

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## THE COVER

The cover illustrates two of the most severe animal damage problems under investigation by the USAID-sponsored International Programs of the Denver Wildlife Research Center (DWRC): rodent and bird damage to agricultural crops both pre- and postharvest. Research at DWRC and in the field involves evaluating a variety of management methods including chemical, physical, cultural, or other techniques that have potential to provide safe, economical, and environmentally sound methods to reduce vertebrate damage in agriculture. The pest species, crop, farming and storage methods, environmental factors, and a host of other considerations may influence the manner in which a particular problem is addressed.

Vertebrate damage in agriculture involves a variety of crops and species of animals, primarily birds and rodents. Direct losses occur typically at planting and sprouting, during the milk or dough stages (for grains), just before harvest, or during postharvest storage conditions. Field projects have been initiated to conduct studies to find ways to reduce or alleviate this damage in several countries of South and Central America, Africa, and Asia.

In many areas of the world, rodent damage to field crops, such as rice in Asia, severely reduces the human food supply and increases the risks to individual farms. In localized areas, rodents may be a principal factor limiting crop production; often, rodents unobtrusively remove a share of production before harvest--crop after crop, season after season. Although there are more than 1,600 kinds of rodents, only about 50 are considered significant agricultural pests.

Agricultural losses to birds are not as well-documented as those to rodents. Various species of parrots, parakeets, blackbirds, weavers, doves, seed-eaters, pheasants, and waterfowl are among the types of birds known to cause damage to agriculture around the world. Actual losses are difficult to assess because damage is usually concentrated in limited areas and, due to the mobility of birds, is often seasonal, sporadic, and hard to predict. The red-billed quelea in Africa is undoubtedly the most important bird pest species in the world.

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ADC | Animal Damage Control |
| AJK | Azad Jammu and Kashmir |
| APHIS | Animal and Plant Health Inspection Service |
| ARA | Agricultural Research Authority (Yemen) |
| BARC | Bangladesh Agricultural Research Council |
| BARI | Bangladesh Agricultural Research Institute |
| BARD | Barani Agricultural Research and Development Project at NARC, Islamabad |
| BGSU | Bowling Green State University (Bowling Green, Ohio) |
| BRRI | Bangladesh Rice Research Institute |
| CPS | Crop Protection Service |
| CSU | Colorado State University (Fort Collins, Colorado) |
| DAE | Department of Agricultural Extension |
| DDVP | Dichlorvos |
| DLCO-EA | Desert Locust Control Organization for East Africa |
| DWRC | Denver Wildlife Research Center |
| FAO | Food and Agriculture Organization of the United Nations |
| EPA | Environmental Protection Agency |
| FSR | Farming Systems Research |
| GSPC | Gassi Seed Production Center (Chad) |
| GTZ | Deutsche Gesellschaft für Technische Zusammenarbeit |
| IPRS | International Programs Research Section |
| IRRI | International Rice Research Institute |
| MOA | Ministry of Agriculture |
| NARC | National Agricultural Research Centre (Pakistan) |
| ORT | Office for Rehabilitation Through Training (Chad) |
| PARC | Pakistan Agricultural Research Council |
| PAF | Pakistan Air Force (PAF) Base, Sargodha |
| PASA | Participating Agency Service Agreement |
| PASSCO | Pakistan Agricultural Storage and Services Corporation |
| RCRP | Rodent Control Research Project (Chad) |
| S&T | Science and Technology |
| STDT | Storage Technology Development and Transfer (Kansas State University) |
| TDY | Temporary Duty |
| USDA | U.S. Department of Agriculture |
| USAID | U.S. Agency for International Development |
| USDI | U.S. Department of the Interior |
| VPCL | Vertebrate Pest Control Laboratory |
| VPCP | Vertebrate Pest Control Project |
| VPM | Vertebrate Pest Management |
| VPS | Vertebrate Pest Section |

# VERTEBRATE DAMAGE CONTROL RESEARCH IN AGRICULTURE

## PREFACE

Increasing food production is one of the most important challenges facing mankind. In some developing countries the disparity between available food and population is both widespread and acute, despite the fact that about one-half of the world's population is actively engaged in agriculture. Millions of people in scores of nations still suffer hunger, malnutrition, and starvation. The reasons are many and complex, but certainly vertebrate pests (primarily rodents and birds) are important factors. Historically, they have not received the degree of attention given to other agricultural pests so that, with few exceptions, little reliable information on the species involved, degree of damage, and the economic impact is available. Damage is, however, unquestionably calculated in hundreds of millions and perhaps billions of dollars annually. Recognizing this, the U.S. Agency for International Development (USAID) has supported a vertebrate pest research and management project within the International Programs Research Section (IPRS) at DWRC since 1967 under Participating Agency Service Agreements (PASA's), as provided for in Section 632B of the Foreign Assistance Act of 1961 (as amended).

The cooperative program was first established between the Administrator, USAID, and the Secretary of the Interior delegating the U.S. Department of the Interior (USDI), 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, IPRS was further transferred from ADC to Science and Technology (S&T) under APHIS. Funds were provided to DWRC by USAID missions and the USAID Bureau of Science and Technology to maintain a core group of international vertebrate pest specialists in the IPRS at the DWRC to implement the cooperative agreements.

The program goal is to evaluate vertebrate pest situations and, when circumstances warrant, develop environmentally acceptable methods to reduce their damage. Goals are accomplished by in-country programs, temporary duty (TDY) activities from the DWRC, supervisory and administrative functions from the DWRC, and problem-oriented research and training using expertise available at the DWRC. The program has been comprised of a DWRC-based outreach project and field station projects in Bangladesh, Chad, Morocco, and Pakistan.

The DWRC-based staff (1) coordinate overall programs, (2) respond to USAID mission requests for problem definition studies and management research, (3) represent the program to other organizations, (4) coordinate DWRC-based training for USAID-funded participants, (5) brief visitors, (6) develop cooperative programs with international organizations and research institutions, (7) provide technical information

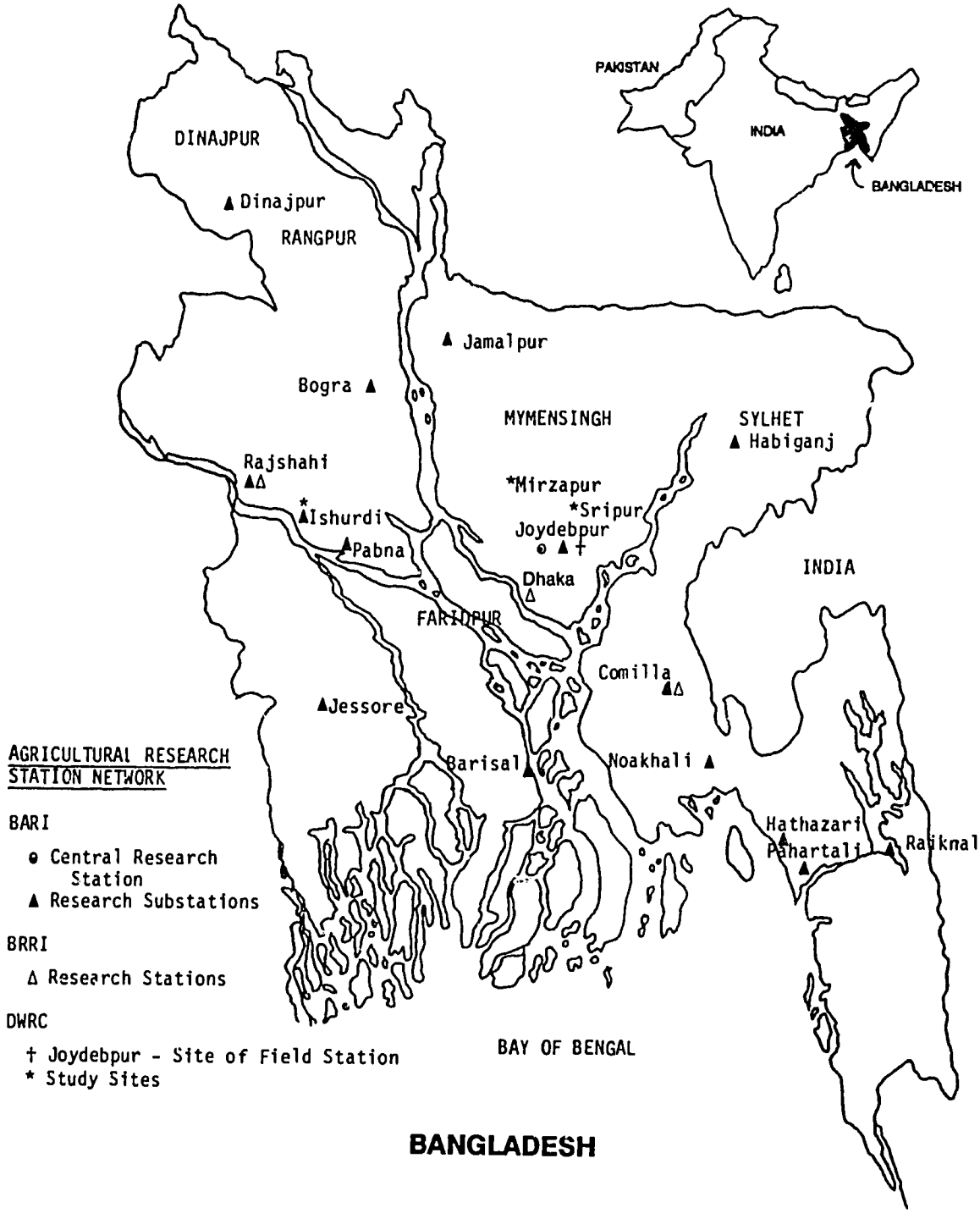
to USAID missions or other cooperators, and (8) assist USAID personnel in program development.

The DWRC field station projects (1) establish the technical capabilities and support within governments and the agricultural sector to conduct programs in vertebrate pest research and management, (2) develop new and adapt existing practical, low-cost, and environmentally sound methods and technology to evaluate and reduce preharvest and postharvest crop losses to vertebrate pests of significant regional importance under local conditions, (3) provide onsite training in research and management methods to reduce losses by vertebrate pests, and (4) help ensure the institutionalization of a vertebrate pest management (VPM) capability in the host country.

For many years, DWRC has been recognized as a leading organization in researching vertebrate pest damage problems and developing useful tools for VPM. Its problem-solving team approach has led to developing and using new methods, materials,[1] and techniques for vertebrate pest control, resulting in monetary savings in many developing countries. The ultimate aim of this pest management research program is to develop safe, effective, and economical control methods which are suitable and practical for traditional farmers and acceptable in the broader context of agricultural development. Self-sustaining, in-country programs are the expected result of this project. Vertebrate damage problems in Africa, Asia, and Latin America are continuously reviewed with the aim of adapting current techniques or materials to specific problem situations in a crop protection-oriented management program which will provide an effective means of long-term crop protection.

The project incorporates a flexible program of applied research, technology transfer, and training. Research activities incorporate laboratory investigations at DWRC and selected laboratories in developing countries with associated field trials at appropriate sites in specific problem areas. A team approach, using the services of an interdisciplinary group of scientists and technicians with diverse backgrounds and experience, coupled with active involvement of foreign investigators, results in practical solutions suited to local requirements. In addition, it creates a professional network for continuing cooperation with indigenous institutions. Training of local counterparts and institutionalization of both research functions and implementation programs are viewed as integral parts of the overall project.

[1] Throughout the report, reference to trade names does not imply endorsement by the U.S. Government or cooperating foreign agencies.

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## BANGLADESH

### Introduction

The vertebrate pest control program in Bangladesh was instituted in December 1978. A Vertebrate Pest Section (VPS) was established within the Entomology Division of the Bangladesh Agricultural Research Institute (BARI) at Joydebpur, 32 km north of Dhaka. USAID/DWRC activities from the onset involved assisting in organizing the VPS, purchasing commodities, developing the laboratory, and implementing research activities. A combination laboratory-office building was completed in July 1979; several outdoor animal facilities have since been added. To date, two Ph.D. scientists and three M.S. scientists have been trained and are working with the Project in a wide variety of laboratory and field research activities and have produced numerous technical reports and publications. The Project has established and is maintaining cooperative ties with the Bangladesh Rice Research Institute (BRRI), the Ministry of Agriculture (MOA), Department of Agricultural Extension (DAE), and other organizations. Backstop support and technical assistance in various aspects of laboratory and field studies are provided by the DWRC. The VPS is developing practical control techniques and strategies, and staff are working with extension personnel throughout the country to implement these strategies. DWRC/IPRS involvement in vertebrate pest research and management activities is funded into June 1993. Project Leaders who have been stationed in Bangladesh include Dr. Michael Jaeger (October 1986-September 1990), Mr. Joe Brooks (1981-1985), and Mr. Richard Poché (December 1978-1980). The Project is being maintained between October 1990 and June 1993 on a TDY basis out of the DWRC.

### Objectives

1. Increase the available food supply.

2. Develop management strategies for important agricultural situations and household stored food.

3. Appraise the nature and magnitude of losses caused primarily by rodents and jackals, and develop (if appropriate) environmentally responsible methods to reduce these losses.

4. Coordinate activities with other organizations to maximize results.

5. Institutionalize in-country research and management programs.

## Transfer of Rodent Control Technology to Farmers

The primary research activity of FY-90 in Bangladesh was to test farmer acceptability for a strategy of controlling rodents when their numbers are at their annual low. Dr. Parvin Sultana (VPS/BARI) coordinated this activity in which individual burrow systems were treated with either Phostoxin® or zinc phosphide during September and early October 1989, just prior to flowering of the main aman rice crop. Rat densities normally increase from an annual low during the monsoon flood period to an annual high that is coincident with the aman harvest. Mr. Lynwood Fiedler, DWRC Wildlife Biologist, assisted in conducting these tests in two 4,800-ha sites that represented the major agroecological zones in Bangladesh. Studies showed that the farmers did use this technology effectively, resulting in a reduction in burrow densities from 3 burrows/ha at the flowering stage to 1 burrow/ha at harvest in treated areas, in contrast to an increase in untreated sites from 4 burrows/ha to 18 burrows/ha. There appeared to be no difference in effectiveness between Phostoxin and zinc phosphide, but zinc phosphide was considerably less expensive. Furthermore, treatment during the September-October period (before rat densities reached their annual high) had a carryover benefit in subsequent wheat and rice harvests in these same plots during March and May, respectively, with burrow densities in the treated 4,800-ha sites still significantly lower than those in the untreated sites. Preharvest damage by burrowing rodents is the most important of vertebrate pest problems in Bangladesh; annual losses are estimated to be between 200,000 and 450,000 metric tons.

This control strategy is not only cost-effective, but it is also environmentally safe. Primary hazards to nontarget animals can be eliminated by inserting the toxicant into the most recently excavated burrow tunnel and sealing the opening. In addition, by treating individual burrow systems when their density is low, the overall dosage of toxicant used can be extremely low.

## Development of a National Action Plan for Rodent Control

As a result of this research, the status of government-sponsored rodent control activities was reviewed by the MOA, DAE, and representatives of BARI, BRRI, and the Bangladesh Agricultural Research Council (BARC). This review recognized that both the national rodent control campaigns and the quality of rodenticides available to farmers needed to be upgraded. A committee was subsequently formed under the DAE Director General to upgrade the national rodent control campaigns by incorporating the technology developed by this VPS/BARI Project. This resulted in the formulation of a National Action Plan for rodent control. The initial phase of the Action Plan was to conduct a large-scale study in seven districts over a 2-year period; the principal objective was to carefully monitor implementation of the campaigns to identify problem areas in the extension process and determine whether cost-effective control had been achieved.

The second outcome of the review was the registration of two additional rodenticides for use in Bangladesh: brodifacoum, marketed as Klerat®, and aluminum phosphide, marketed as Phostoxin. These had been field tested by the Project and demonstrated

to be cost-effective. In addition, both are preformulated and checked for quality before marketing. Up to this time, zinc phosphide had been the only alternative for most farmers. Problems with quality control, adulteration, and the need for farmers to formulate baits of proper concentration and dosage greatly limited its effectiveness.

## Country-wide Survey of Rodent Control Practices

Between February and April 1990, 512 farmers from 16 sites scattered throughout Bangladesh were sampled by questionnaires to determine their understanding of, and participation in, rodent control. The overall objective was to determine the specific training needs of the farmers and the most effective medium through which to pass this information. Results indicated that a high percentage of farmers attempted rodent control, but with questionable effect. Most farmers reported using zinc phosphide which they formulated themselves. Training needs include defining proper procedures for formulating zinc phosphide baits, identifying rodent species causing damage, and determining when and where to focus control efforts for cost-effective results. Farmers received most of their information from pesticide salesmen, posters, and radio programs; only 10% had contacted an extension agency during the past year.

## Jackal Research

Research continued on a long-term study comparing jackal damage to poultry and livestock relative to the benefits of jackal predation on rats. Rat damage to preharvest rice and wheat is the more important problem. Earlier work showed that rats are an important component in the jackal's diet, and it was hypothesized that in situations where rats are concentrated in a relatively small area (e.g., in maturing wheat), predation by jackals might significantly reduce rat damage.

During FY-90, Dr. Michael Jaeger and Mr. Rajat Pandit, Scientific Officer, VPS/BARI, evaluated the use of broadcasted howling as a means to determine the relative abundance of jackals in agricultural areas of Bangladesh. The test was conducted by counting the number of animals howling in response to broadcasts of taped jackal howls. Results indicated (1) that the elicited response to howling is a potentially useful means for determining relative abundance and minimum densities, and (2) minimum densities of about 2.5 jackals/km$^2$ have the potential to reduce rat damage. The use of this method seems practical and potentially valuable for providing information on the number of territorial groups in an area and on breeding success during the year. Jackal responsiveness, however, is complicated by variation between individuals and groups, and it appears to be affected by season, time of night, and moonlight.

Mr. Joe Brooks, Wildlife Biologist, has recently analyzed data collected while he was DWRC Project Leader in Bangladesh on farmer perceptions of the golden jackal (*Canis aureus*) as a pest in Bangladesh. A survey of farmers' perceptions of the agricultural and economic importance was conducted between May 1983 and November 1984 in 11 districts of Bangladesh that represented several differing physiographical and ecological

areas of the country. Of 1,110 farmers surveyed randomly, 26% reported crop damage and 62% lost domestic animals to jackal attacks. In 1984, 589 farmers reported the loss of 4,233 chickens, while 231 lost 521 goats and 162 lost 632 ducks. Jackals reportedly damaged sugarcane, melons, pineapple, jackfruit, maize, groundnut, cucumber, and a variety of other crops; they also consumed chickens, ducks, goats, sheep, pigs, calves, pigeons, and freshwater prawns. Annual losses of crops, livestock, and poultry averaged $16.12 per farmer, a large amount in a country where the annual per capita income is less than $100. Predation was the most intense during June, July, and August. Although jackals were reported at every village surveyed, they were more abundant and destructive in the southern districts of the country. The jackal has successfully adapted to the densely human-populated, intensely-cultivated agroecosystems of Bangladesh.

Jackals were captured, fitted with radio transmitters, and released to study home range and damage patterns to sugarcane and livestock.

Rat damage to sugarcane at harvest time (above) and golden jackal damage to sugarcane (below) is found in fields in the Sripur area, Bangladesh.

## Vertebrate Pest Section Field Research Activities

After the departure of Project Leader Dr. Michael Jaeger in September 1990, VPS scientists continued to conduct several research studies. Research included (1) rodent and jackal damage assessment of sugarcane, (2) estimation of livestock losses due to vertebrate predators, (3) bird damage assessment in maize, and (4) efficacy of three carbamate insecticides in controlling bird damage to fox-tail millet. In addition, several manuscripts of VPS research are now in various stages of preparation.

## Training

During the past 2 years, Bangladeshi Project scientists provided several specialized training courses and participated in other training opportunities:

1. Prior to the National Rodent Control Campaign scheduled for October 15-29, 1991, Mr. Md. Emdadul Haque, Senior Scientific Officer, VPS, and Dr. Md. Abdul Karim, Head, Division of Entomology, provided training on rodent control techniques to district deputy directors and subject matter specialists within the DAE in the Dhaka Division (34 participants), Chittigong Division (30), Rangpur Division (32), and Jessore Division (32).

2. Messrs. Haque and Rajat K. Pandit, Scientific Officer, VPS, presented information on vertebrate pest damage and conducted field visits for 27 MOA scientific officers and seed analysts in the BARI training course "Collection and Identification Techniques of Plant Pest and Diseases," held August 26-31, 1991.

3. Mr. Haque presented a paper on rat species identification, biology, and nature of damage at the "Action Plan for Rodent Control in Bangladesh" held at the Jamalpur and Comilla District for the officers of Road and Highway, Subject Matter Specialists, Water Development Board, and Bangladesh Railways during October and November 1990.

4. Mr. Haque presented a paper on vertebrate pests and their control for new recruited scientific officers of BARI during a 2 months' training course held at BARI facilities in November and December 1990.

5. BARC and BARI sponsored the training course "Research, Planning and Evaluation" at the BARI facilities. This course was attended by Mr. Pandit (April 4-19, 1990), Mr. Haque (March 10-25, 1990), and Mr. Habibur Rahman, Scientific Officer, VPS (October 23-November 6, 1990).

6. Dr. Sayed Ahmed, an International Rice Research Institute (IRRI)-sponsored Ph.D. candidate from BRRI, completed his research in vertebrate pest management and received his doctorate from Colorado State University (CSU) in the spring of 1991. He conducted research for his thesis on "Development of a toxicant delivery system utilizing rodent grooming behavior" at the DWRC.

7. Mr. Yousuf Mian, Senior Scientific Officer, VPS, and DWRC Project counterpart from BARI, continued his Ph.D. program at CSU, which emphasizes statistics, modeling, and computer use in describing and evaluating vertebrate pest problems.

8. Mr. Santosh K. Sarker, DAE, continued his Ph.D. research at Dhaka University; his thesis is on "Evaluation of rodent control strategies in Bangladesh."

9. Mr. Md. Emdadul Haque has completed course requirements at Dhaka University and is finishing his doctoral thesis on "Biology, ecology, and control of the short-tailed mole rat, *Nesokia indica* (Gray), in Bangladesh."

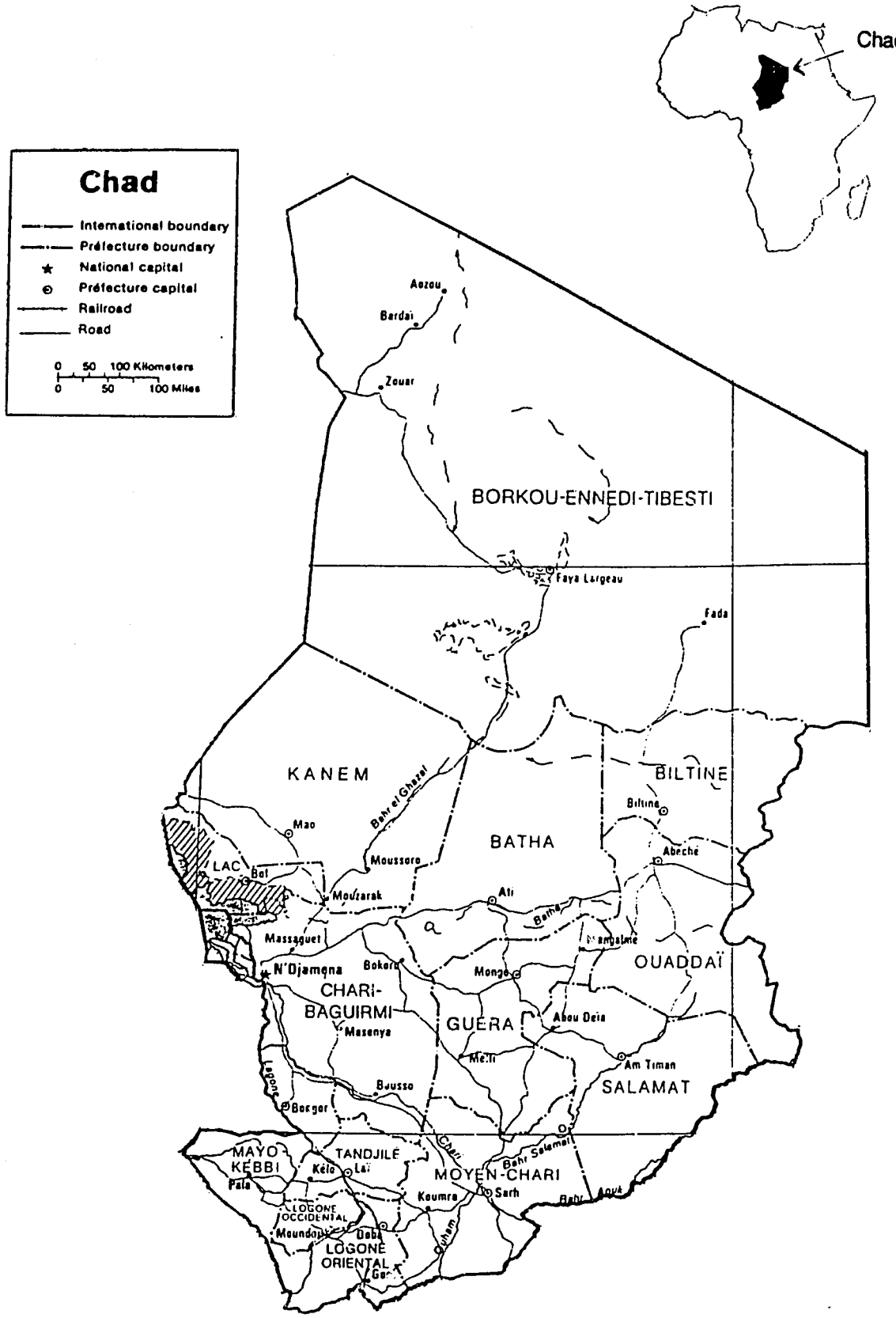
**Technical Assistance from DWRC**

In addition to the practical experience obtained in the field, DWRC arranged for visiting consultants to provide training for Project staff. From November 18 to December 15, 1989, Dr. Robert Timm, Superintendent and Extension Wildlife Biologist from the Hopland Field Station for the University of California, assisted Mr. Santosh Sarker, DAE, in developing a questionnaire for use in the country-wide survey of farmers to determine their acceptability of the rodent control technology developed by the Project.

Between January 15 and February 17, 1990, Dr. Frederick Knowlton, DWRC's Field Station Leader in Logan, Utah, assisted Mr. Rajat Pandit, VPS/BARI, in developing the predator research program, specifically in evaluating the data on howling responses and planning the future direction of predator research. In addition, Dr. Knowlton provided basic computer training in Lotus 1-2-3 to VPS/BARI staff.

Ms. Paige Groninger, DWRC Computer Programmer Analyst, assisted VPS/BARI staff from February 13 to March 5, 1990, with setting up a system of computer menus and submenus to facilitate program choices and instructed Project staff in their use. She also provided instruction in the use of WordPerfect, Lotus 1-2-3, HOME RANGE, and SAS, particularly as applied to the specific research needs of the staff.

Dr. Richard Bruggers, Chief, IPRS, was in Bangladesh from February 28 to March 10, 1990, to meet with Project staff and USAID personnel to formalize continuation of DWRC assistance to the VPS through June 1993.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# CHAD

## Introduction

The Chad Rodent Control Research Project (RCRP) was initiated in October 1989 as a cooperative program of the USDA/APHIS, AID/N'Djamena, and Chadian MOA/ Crop Protection Service (CPS). Funding was provided by AID's Africa Emergency Locust/Grasshopper Project. The rodent monitoring program was developed from DWRC consultancies in response to an earlier Sahelian rodent outbreak. In October 1989 Chadian scientists began to systematically monitor rodent populations. Project Leader Dr. Juan Spillett arrived in N'Djamena, Chad, on July 3, 1990. Since the Project's inception, DWRC personnel have provided technical, logistical, and administrative support and assistance. The Project completion date is December 31, 1992.

## Background

The Sahelian Region encompasses about 3 billion hectares (20%) of Africa and includes portions of nine African countries (Cape Verde, Mauritania, Senegal, Gambia, Burkina Faso, Mali, Niger, Chad, and Sudan). More than 30 million people inhabit the Sahel; of these, 80% are rural and directly dependent upon agriculture. The Sahel has one of the world's highest population growth rates (3-5% per annum); its population is expected to exceed 50 million people by the year 2000. The Sahel was once a major food-producing area for northern Africa, but it is now a food-deficit region due to droughts and, among other reasons, crop depredations by birds, rodents, and insects.

In 1986 several Sahelian nations declared national disasters due to massive outbreaks of rodents. USAID was hampered in providing assistance due to a lack of knowledge of the rodent species concerned, their population dynamics, and effective control measures. Short-term technical assistance was provided by the USDA/APHIS/DWRC in the form of eight TDY's to the Sahel between April 1, 1987, and November 10, 1987. The crisis response was inadequate due to poor organization and lack of trained in-country personnel, materials, transportation, and time to implement needed control measures. To ensure the implementation of effective crop protection measures in the future, it was felt essential to conduct research into rodent biology and control methods; therefore, research was initiated to monitor rodent populations, evaluate control techniques, and train CPS personnel to effectively address future reoccurring rodent population irruptions, such as occurred in 1962, 1977, and 1986-87 in the Sahel.

## Objectives

The overall goal of the RCRP is, through research and a better understanding of the rodent pest situation, to help African countries in the Sahel achieve a greater degree of food security. The primary objectives of the work in Chad, where the Project is based, include:

1. Obtain laboratory and office space, facilities, equipment, and supplies.

2. Identify the major rodent pest species involved in crop depredations in the host country.

3. Determine the reproductive biology and population dynamics of major Sahelian rodent pest species through systematic rodent population monitoring.

4. Assess quantitatively rodent damage to selected Sahelian agricultural crops.

5. Develop effective, safe, economical, and acceptable methods for rodent control.

6. Provide training and/or guidelines to the MOA/CPS whereby effective long-term rodent population monitoring and control programs can be implemented.

## Accomplishments

A Project vehicle was acquired in September 1990, and the Project office/laboratory facilities in the MOA/CPS complex were renovated by October 1990. To date, four Project technicians, numerous MOA/CPS extension agents, and other personnel have been trained in various aspects of rodent biology, population monitoring, and control. Between October 1989 and September 1991, sampling and monitoring of rodent populations on wadi and dune agricultural sites have been conducted at approximately monthly intervals in the N'Gouri area. Similarly, since August 1990, sampling and monitoring of rodent populations on recessional agricultural lands south of Lake Chad have been conducted at approximately monthly intervals in the Karal area. Limited field and laboratory trials on the efficacy of zinc phosphide baits have also been conducted, and bait preference trials with the unstriped grass rat or Nile rat (*Arvicanthis niloticus*) have been initiated under controlled conditions.

## Rodent Pest Identification

"Wadi" agriculture is the cultivation and irrigation (by hand, from shallow wells) of small, scattered oases, within which crops such as onions, tomatoes, peppers, okra, manioc, sorghum, and millet are grown. In 20 sampling periods from October 1989 through September 1991, the primary rodent pest of wadi crops was identified as *A. niloticus*. The Anderson's gerbil (*Gerbillus andersoni*)[1] and the fringe-tailed gerbil (*Tatera robusta*) are pests of lesser significance in wadis (Fig. 1).

"Dune" agriculture is the extensive dryland hand cultivation of primarily millet (but some sorghum) on dunes or sandy hills surrounding widely scattered wadis. In 19

[1] This species was identified by Dr. Sohail S. Soliman, Mammal Ecologist and Taxonomist, Ain Shams University, Cairo, Egypt.

sampling periods from November 1989 through September 1991, the primary rodent pest of dune millet crops was identified as *G. andersoni*. Only a few *A. niloticus* and other rodent species, such as the lesser Egyptian jerboa (*Jaculus jaculus*) were represented in trapped samples from dunes (Fig. 2).

"Recessional" agriculture is the hand-cultivation of crops (i.e., rice, corn, sorghum, millet, cow peas, peanuts, manioc, okra, sweet potatoes, watermelon, cantaloupe, gourds, and tomatoes) on lands which are seasonally flooded, but on which crops are planted after the waters recede. During 12 sampling periods from August 1990 through September 1991, it was found that the major rodent pest species of recessional crops are *G. andersoni*, the multimammate rat (*Praomys natalensis*), and an unidentified mouse (*Mus* sp.) (Fig. 3).

## Rodent Population Monitoring

Rodent populations on 8-11 wadis and 3-4 dune sites in the N'Gouri area have been monitored at approximately monthly intervals since October 1989. Similar rodent population monitoring was initiated in recessional agricultural crops or vegetation types in the Karal area in August 1990. Data derived from this intense sampling scheme will be used to develop a simpler monitoring program that can be applied over a wider area by MOA/CPS personnel. Guidelines will be developed so that long-term rodent population monitoring can be effectively implemented and control measures undertaken prior to the rodent outbreaks and resultant large-scale damage.

Crops in Sahelian Chad are frequently grown in interdune depressions called wadis.

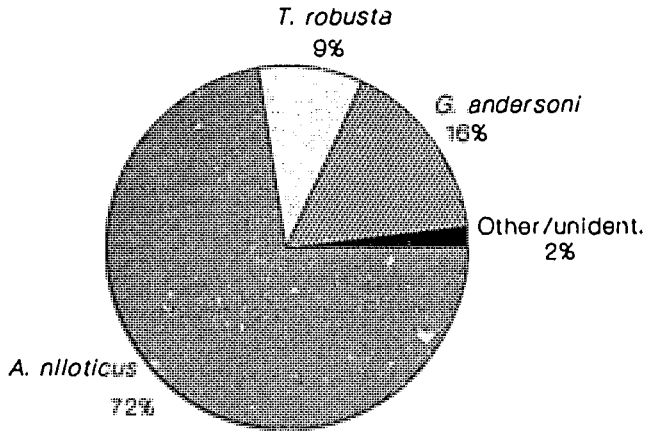



**Fig. 1. Rodent species trapped from wadis near N'Gouri, Chad**

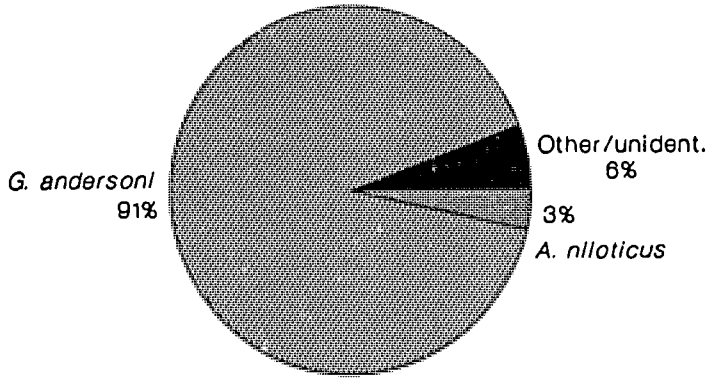



**Fig. 2. Rodent species trapped from dunes near N'Gouri, Chad**

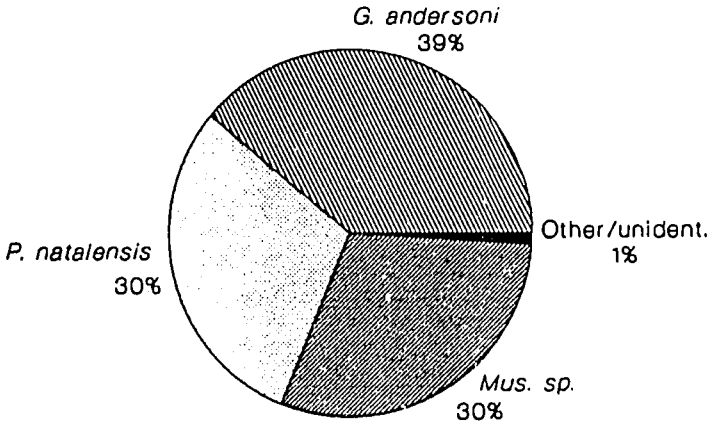
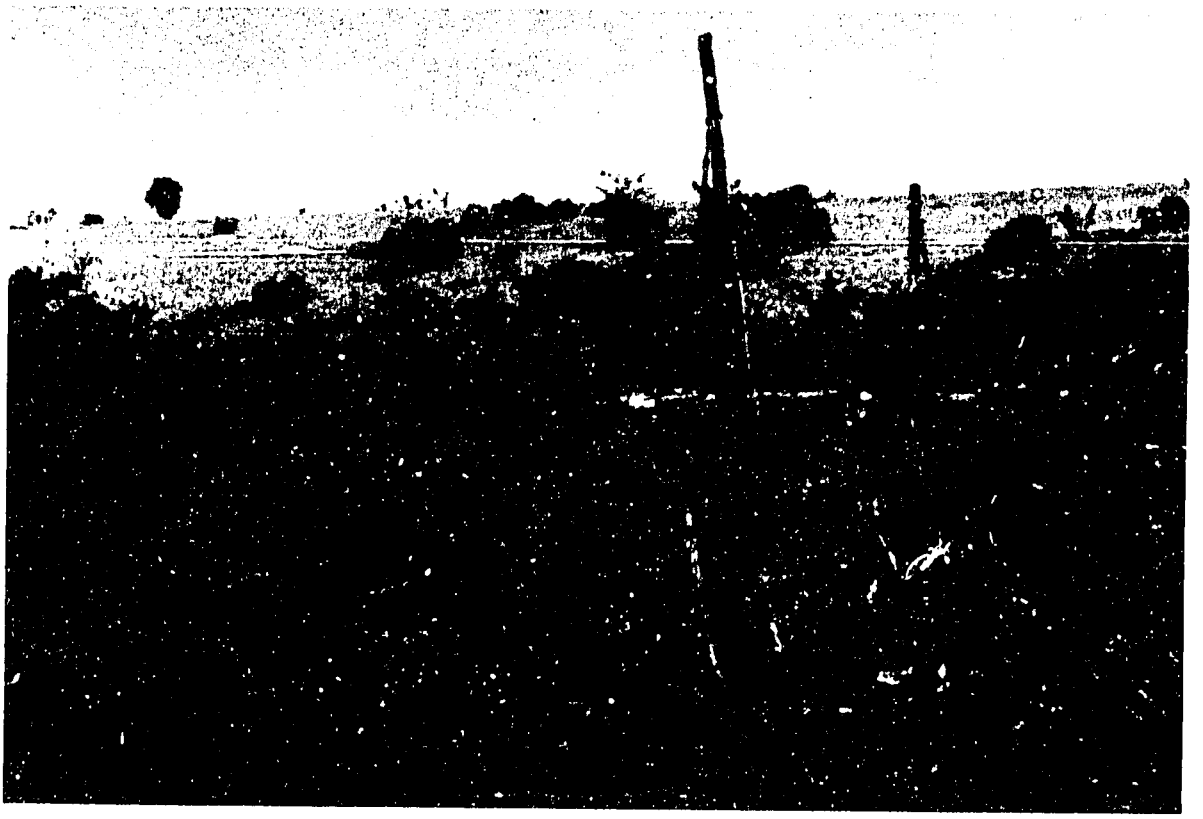



**Fig. 3. Rodent species trapped from recessional agricultural areas near Karal, Chad.**



Irrigating wadi crops occupies much of a farmer's time.
Water is raised from the well in a basket.

## Rodent Population Dynamics

Collections of rodents during sampling have been small, because of extended, severe drought in the Sahel during 1990 and 1991. Trap success from February 1990 through July 1991 rarely exceeded 2% and was usually less than 1%. Data reflect that rodent populations are dependent upon rainfall and subsequent vegetational growth and that the rodent reproduction rate is directly related to the available food supply, rather than season. Mean litter sizes recorded from trapped samples of pregnant females for *G. andersoni*, *A. niloticus*, *P. natalensis*, and the unidentified *Mus* sp. are 5.1, 7.1, 9.9, and 5.0 respectively.

## Rodent Control Techniques

Because toxicant acceptance usually requires an attractive bait, diversity in both rodent pest species and agricultural crops in the Sahel compound the problem of effectively controlling rodents from damaging crops. Four common food grains in the Sahel (millet, sorghum, corn, and rice) were used to conduct bait preference trials under controlled conditions with *A. niloticus*. Millet was the most preferred of these four cereal grains. Limited trials indicated that 1% zinc phosphide ($Zn_3P_2$) baits may effectively control major Sahelian rodents pests; this needs further research. Literature suggests

that using toxicants may be the most effective method to quickly reduce high density or irruptive rodent populations, such as those which occur periodically in the Sahel. However, in cooperation with an "Office for Rehabilitation Through Training" (ORT) Project in the N'Gouri area, a comparative study of the use of snap traps, pit traps, and bait stations for rodent control in wadi agricultural sites will be evaluated.

### Research Activities in the N'Gouri Area

The N'Gouri area, which is located approximately 230 km north of N'Djamena, typifies Sahelian "dune" and "wadi" cultivation. Rodent population sampling with snap traps was initiated on eight wadis in the N'Gouri area in October 1989. In November 1989, three dune cultivation areas were added to the sampling sites. An additional wadi was sampled during the June 1990 sampling period, and an additional dune site (a total of four dunes) and two more wadi sites (a total of 11 wadis) were sampled in

Nearly 2,000 traps are set monthly to sample rodent populations. The data should provide the information necessary to both determine chronic rodent densities and predict rodent irruptions.

July and September 1990. Between October 1989 and mid-August 1991, 19 field trips (sampling periods) of 5-9 days each were conducted in the N'Gouri area. A total of 20,924 traps (3,100 in dune sites and 17,824 in wadi sites) were set, of which 19,180 (2,782 in dunes and 16,398 in wadis) were considered as "effective" trap days and/or nights. A trap which is lost or is sprung without capturing a rodent is considered "ineffective." Six hundred and sixty-nine rodents (133 in dunes and 536 in wadis) were captured. This is an overall "trap success" of 3.5% (4.8% in dunes and 3.3% in wadis).

Trap success (the number of rodents captured/effective traps set) has consistently declined since sampling was initiated in October 1989. Some of this decline probably can be attributed to the fact that six wadis were treated with the rodenticide chlorophacinone in late December 1989 or early January 1990. However, trap success on untreated wadi and dune sites has been consistently low between the May and September sampling periods. For example, only 17 rodents were captured during 1,519 effective trap nights conducted on dune sites between May and mid-September 1990 in the N'Gouri area. This is only a 1.1% trap success (Fig. 4).

Sex ratios have been predominated by males. Ninety-five (73%) of the 131 rodents trapped and sexed on dune sites were males; 243 (59%) of the 413 rodents trapped and sexed on wadi sites were males.

Sample sizes for most trapping periods are too small to provide definitive conclusions relative to reproduction or the presence of embryos in trapped samples of sexually mature female rodents. However, relatively few embryos were observed in mature females from January until September 1991, particularly in comparison with what was observed during October-December 1989 and late July-September 1990.

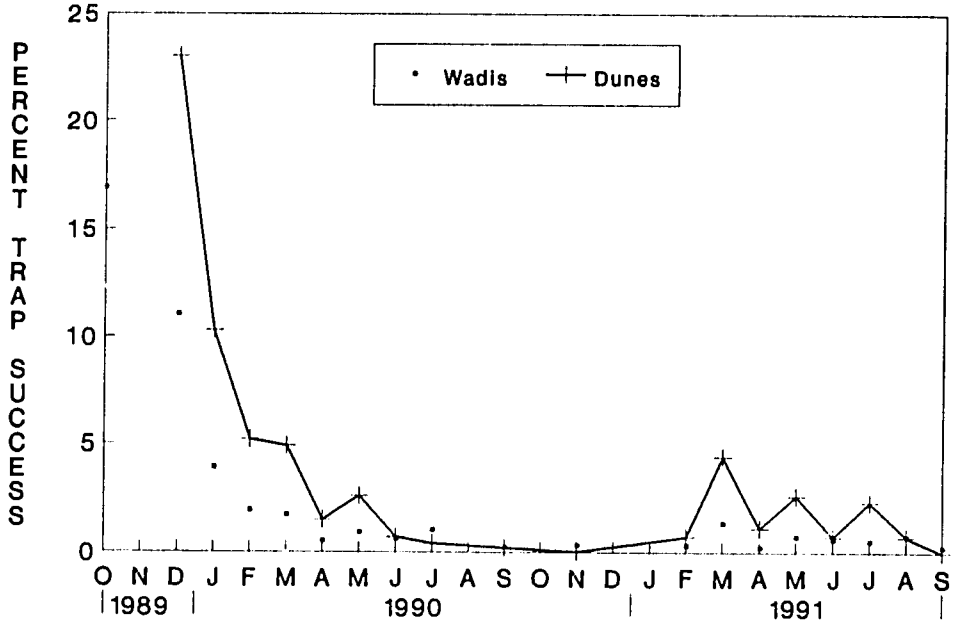



**Fig. 4. Trapping success (wadis and dunes) at N'Gouri**

Rodent research Project personnel are monitoring monthly rodent densities by sampling populations near N'Gouri.

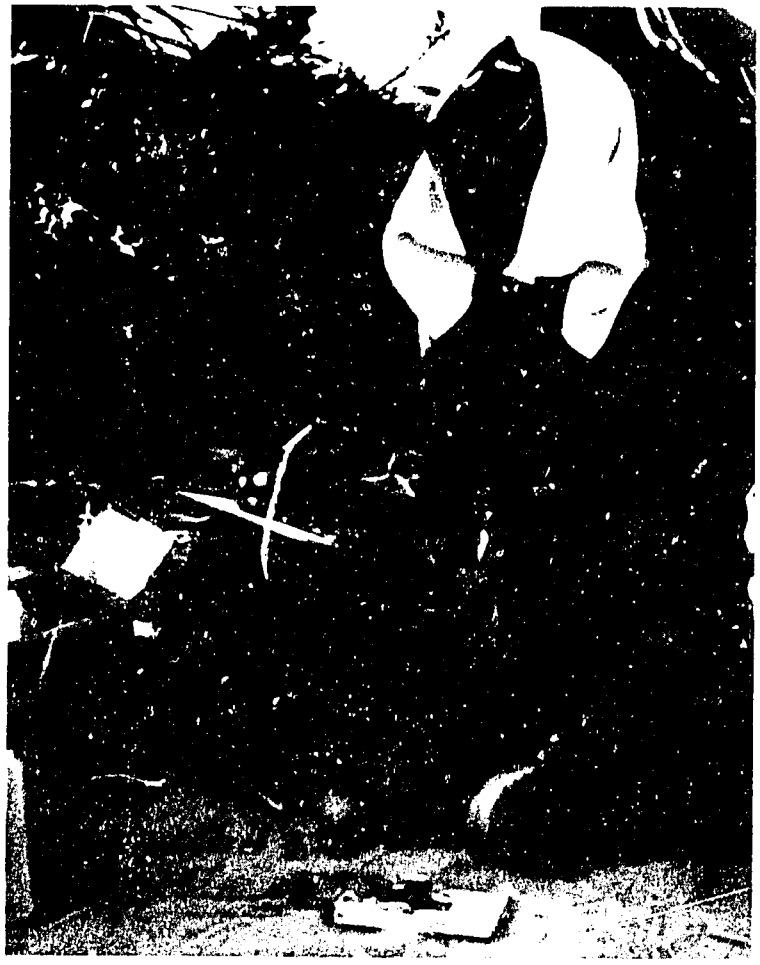
## Research Conducted in the Karal Area

The Karal area, which is located about 130 km north of N'Djamena, typifies the "residual" or "recessional" type of agriculture common around Lake Chad and other areas in the Sahel where water collects during the relatively short rainy season and then recedes or dries up during the following dry season. Generally, recessional cultivation is much more dependable and productive than dune cultivation. Also, it is much less labor intensive than the wadi system, and it has potential (as yet, unrealized) for crop production. Perhaps a major reason why potential agriculture productivity in the Karal area has not been realized is because of a lack of transportation or roads upon which to transport produce to markets. However, a quality road to Dandi, which is about 20 km south of Karal, presently is being constructed from the N'Djamena to Massakory thoroughfare. This road should be completed within the next 2 years. Thus, agricultural production in the Karal area could become of major importance in providing produce for the N'Djamena market and helping Chad achieve "food security" in coming years.

During the first visit to Karal (August 6-9, 1990), considerable time was spent obtaining information and assistance from the Secours Catholique pour le Developpement, a Catholic church agricultural development organization that has been working in this area for many years. Various sites were visited, and traps were set in different agricultural crops to sample rodent populations. One thousand and seventy-eight traps were set for 935 "effective" trap nights. Twenty-two rodents (2% trap success) were captured: 10 (45%) were *G. andersoni*, 8 (36%) were *P. natalensis*, and 4 (18%) were *Mus* sp.

Based upon the above data collected in the Karal area, the next areas sampled between September 12 and 14, 1990, were near the villages of Beltram (approximately 15 km north of Karal) and Guitte (approximately 25 km west of Karal). Out of 1,050 traps that were set, 950 were "effective," resulting in 21 rodents being captured (a trap success of 2.2%). Continued trapping in the Karal area up to September 1991 revealed a declining rodent population after November 1990. Trap success dropped to less than 1% in the period up to September 1991 (Fig. 5).

One field trial of toxicant efficacy was initiated near Karal on October 16, 1990. Fields of groundnut, gourds, and uncultivated land near irrigation ditches from the flood waters of Lake Chad were found to have rodents. To identify active burrows, all openings in the fields were closed. The next morning, 12 of the 39 burrows were opened. A 1% zinc phosphide bait was then formulated (1 g of 80% active ingredient zinc phosphide + 1 g of peanut oil + 98 g of rice). Using a teaspoon, 89 g of bait were placed about 6-8 inches inside each of the 12 opened burrows. Each treated burrow was then covered in successive order with vegetation, a piece of tissue paper, and dirt. On October 18, all 12 baited burrows were still closed. A qualitative estimate was made of the amount of zinc phosphide bait that was consumed: in 3 burrows, a minimal amount of bait was consumed; in 5 burrows, a moderate amount of bait was consumed; and in 4 burrows, the consumption was high. This limited field test indicated that 1% zinc phosphide bait was highly effective. The burrows were probably made by *P. natalensis* or *A. niloticus*.



**Data from the monthly rodent monitoring are carefully recorded.**

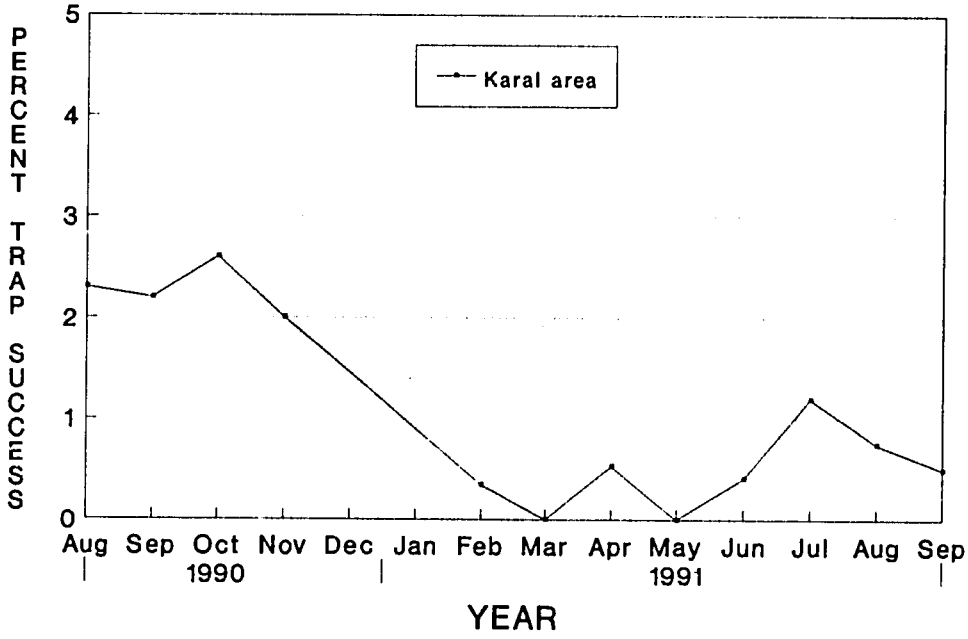



**Fig. 5. Trapping success in the Karal area.**

### Need for Research in the Abeche Area

Tentative sites for rodent population studies in the Abeche area of eastern Chad were identified by Dr. John Wilson in October 1989. However, intensive data collection was not initiated due to travel and funding constraints.

Drs. Son Nguyen and Nabassen Namde visited the Abeche area in early August 1990 regarding another USAID project. While there, they took some RCRP snap traps with them and conducted some rodent sampling for this Project. They captured approximately 10 rodents (about a 5% trap success for 200 trap nights). This information, as well as reports from farmers and agricultural advisers with whom they met, indicated that rodents were (or might become) a serious pest problem in the Abeche area. If possible, sampling in the area might be considered on a quarterly basis in the future.

## Training

The training of counterpart Chadian MOA/CPS personnel in rodent biology, ecology, population monitoring, and control has been an ongoing and integral part of RCRP. Even before the Project was established, Dr. Clay Mitchell, DWRC Wildlife Biologist, in his 1987 consultancy to Chad, trained 9 extension agents in bait formulation and 29 extension agents in methods of bait application and evaluation. In 1988, Mr. Keith LaVoie, DWRC Wildlife Biologist, likewise trained Chadian MOA personnel in safe, effective methods for warfarin grain bait application and evaluation in wadis. During October 1990, Dr. Peter Savarie, DWRC Research Pharmacologist, trained Project personnel in laboratory animal handling procedures, gavage techniques, dose level formulations and calculations, and rodenticide bait formulations. In April-May 1991, Mr. Joe Brooks instructed Project personnel in procedures for conducting bait preference trials with rodents and assessing rodent damage to selected agricultural crops.

RCRP personnel trained 18 MOA/CPS technicians in rodent research and control during a Pest Management Workshop which was held in N'Djamena November 26-27, 1990. Information developed by Dr. Savarie on the "Toxicity of Rodenticides" that emphasized the toxicity and safety aspects of using zinc phosphide and warfarin was included in this workshop. RCRP staff also conducted a field demonstration at the Gassi Seed Production Center (GSPC) south of N'Djamena. The purpose of this experiment was to determine the significance of crop losses due to rodents. Considering estimated rodent density per hectare, weight of the rats, average daily consumption, and amount of crop eaten, an annual crop loss at GSPC was calculated to be at least almost 6 kg/rat/year. Estimating the annual sorghum production on the sample area to be about 1,000 kg/ha and losses due to rodents at 45.6 kg/ha, the expected crop loss would be approximately 5% of the total sorghum production.

Several editions of "Rat Facts," a one-page informational sheet produced by the RCRP, have been distributed to Chad/MOA, AID/N'Djamena, and DWRC personnel since September 1990. Each issue has been printed in both English and French. The initial edition highlighted the Sahel and its need for rodent control. Subsequent editions have

dealt with various rodent pests, rodent population monitoring, assessing crop losses due to rodents, and diseases that rodents can transmitted to man.

Mr. Abdelwahib Yacoub, former Project Assistant, left Chad in early June 1990 to pursue an M.S. degree in Agriculture Economics at Michigan State University, East Lansing, Michigan. Mr. Dourbaga Maila, former Project Technician, left the RCRP in January 1991 to take 2 years of advanced technical training in Niger.

**Technical Assistance from DWRC**

Three consultancies were made to Chad during 1987 and 1988 to survey the rodent situation and determine the logistical considerations and requirements for establishing a rodent control field station with a DWRC biologist working in Chad. Since the inception of the RCRP in October 1989 through September 1991, the DWRC has supplemented this rodent research project with seven additional TDY's to Chad.

Dr. John Wilson, Research Director, Centre for Biological Population Management, Queensland University of Technology, Brisbane, Australia (on sabbatical at DWRC), consulted for the DWRC/IPRS in Chad between October 11 and November 9, 1989, to assist the AID/N'Djamena and MOA in initiating a rodent monitoring study. Mr. Keith LaVoie was also in Chad from October 8 to 20 to work with AID/N'Djamena on plans for laboratory facilities and housing for the planned USAID/DWRC project in Chad, and Mr. LaVoie accompanied Dr. Wilson to the N'Gouri area where they initiated a long-term rodent monitoring project.

During this time, monitoring sites were established in two subregions (N'Gouri and Abeche). The monitoring sites encompassed the range of habitats available to rodents in the subregions. Bait trials were undertaken in various habitats to determine a suitable bait for use during the remainder of the study. The counterpart and cooperators were trained in trapping, autopsy and data coding techniques, and the initial monitoring of rodent population density and structure was implemented in the N'Gouri subregion. Three hundred and thirteen animals were trapped over 2,200 trap nights with the dominant species being *Arvicanthis niloticus* (over 80% of total captures). *Gerbillus andersoni* was dominant in the dune systems (15% of total captures) with isolated captures of *Mastomys* sp. and an unidentified *Gerbillus* sp. in wadis. The counterpart and cooperators from the Chadian MOA continued monitoring these sites on a monthly basis. Regular monitoring through several rodent population cycles (or for at least a couple of years) is essential for establishing the database necessary to understand population demographics; in the long term, this information should prove valuable toward forecasting rodent outbreaks.

Dr. Richard Bruggers traveled to Chad from November 20 to 29, 1989, to consult with AID/N'Djamena and MOA personnel and assist with administrative matters necessary for implementing the USAID/DWRC rodent research field station. Dr. Bruggers also tried to travel to Chad on December 1, 1990, but his flight was diverted to the Central African Republic due to a *coup d'etat* in Chad.

Mr. Keith LaVoie returned to Chad between April 1 and 25, 1990, to continue field work and training for determining rodent species composition and monitoring rodent densities in Sahelian agricultural areas. This TDY permitted making timely changes in field sampling methods as well as determining the progress and plans for the facility at the field station.

Dr. Juan Spillett joined the DWRC/IPRS staff in June 1990. He participated in briefing sessions at DWRC and in Washington, D.C., before assuming his duties in Chad as Project Leader on July 3, 1990.

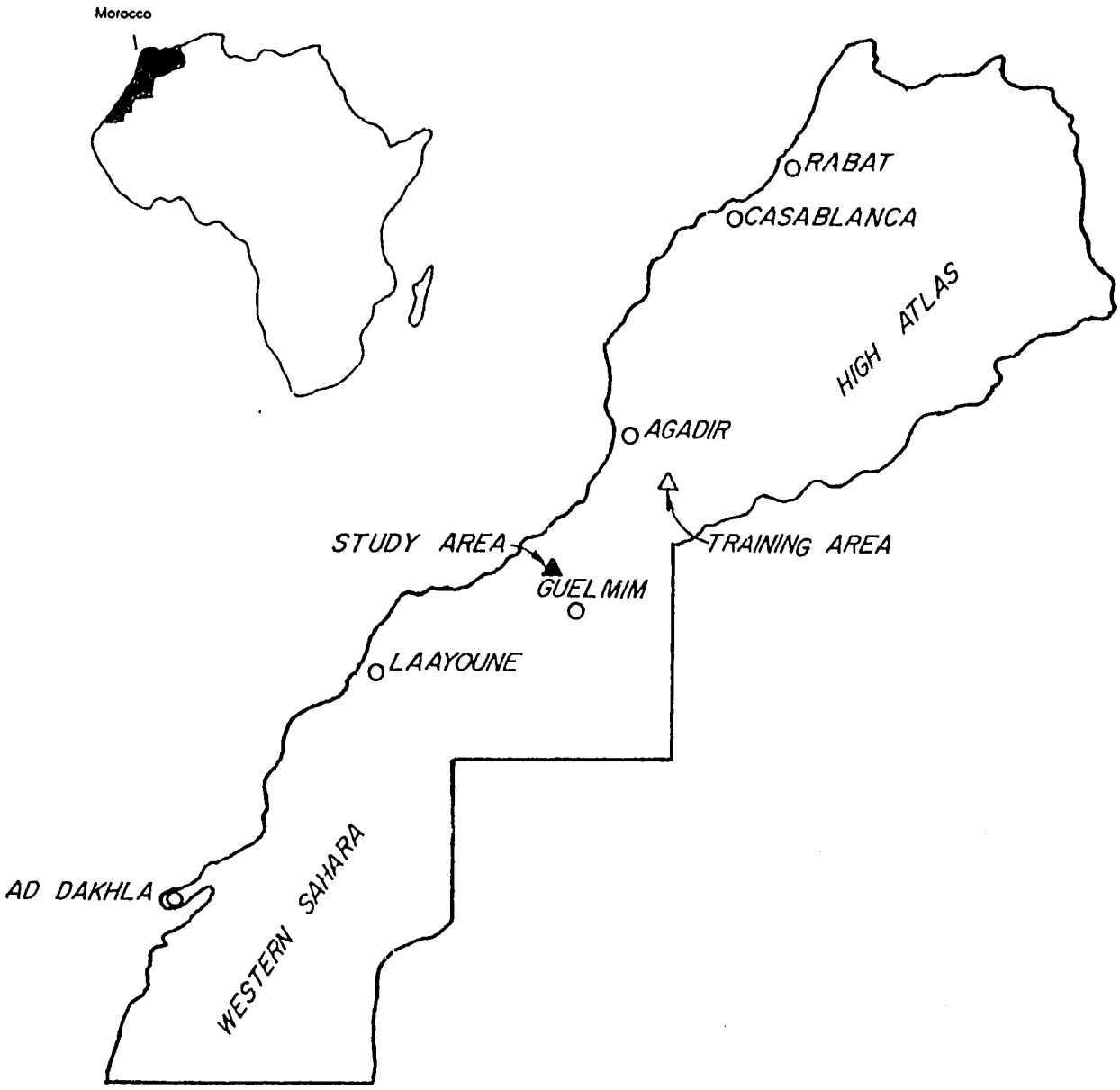
Dr. Peter Savarie traveled to Chad from October 7 to 31, 1990, to assist with rodent research and training activities. He cooperated with Dr. Spillett and Dr. Mornan Kounade, Project Assistant, in developing a rodenticide toxicity lecture for a workshop on rodent control research to be held for Chadian MOA/CPS technicians in November 1990. Dr. Savarie also trained Project personnel in procedures and techniques for laboratory and field testing of rodenticides.

During December 1990, Project Leader Juan Spillett was temporarily evacuated from Chad for political reasons. Dr. Spillett spent much of this interim time analyzing data and drafting material on population characteristics of rodents in Chad, prior to resuming his duties as Project Leader on March 15, 1991.

Mr. Joe Brooks consulted in Chad between April 5 and May 1, 1991, to assist in developing methods to assess rodent damage to vegetable crops, initiate baiting trials to determine which baits best deliver toxicants to rodent pests, and develop simpler methods for implementing the long-term rodent population monitoring program.

Mr. LaVoie (retired since his previous trip) returned to Chad between August 10 and September 4, 1991, to assist in monitoring rodent populations at two agricultural sites and in initiating a study comparing rodent control methods. The monitoring data suggested that populations of all the main agriculturally important rodent species were increasing. These increases likely were due to improved habitat conditions resulting from the first rains in over 2 years. The populations were not likely to result in major outbreaks, but they should provide animals needed for bait preference, rodential toxicity, and small, comparative field control trials, such as the recent initiated trial comparing the effectiveness of locally made steel rat traps, pit traps, and rodenticides.

# MOROCCO


Morocco
RABAT
CASABLANCA
HIGH ATLAS
AGADIR
STUDY AREA
TRAINING AREA
GUELMIM
LAAYOUNE
AD DAKHLA
WESTERN SAHARA

# MOROCCO

## Introduction

An eruption of desert locust (*Schistocerca gregaria*) occurred through the African Sahel between 1986 and 1988. Affected African countries responded by initiating surveillance and control programs with the assistance of international donors. To protect agricultural crops and rangelands, Morocco intensively used insecticides to control the locusts. Over 2 million ha south of the Anti Atlas Mountains were treated in 1988 alone. Most treatments consisted of using the organophosphate insecticides, malathion, dichlorvos (DDVP), fenitrothion, fenthion, and diazinon. Synthetic pyrethroids and the carbamate carbaryl were also used, but to a lesser degree. All of these materials are broad spectrum insecticides. They are capable of killing most arthropods and thereby disrupting the community ecology of invertebrates and vertebrates on treated areas. Several organophosphates are capable of causing mortality in birds. The ecotoxicological risk of pesticide use in arid regions is virtually unknown. Since most knowledge on the hazard of insecticides has been developed in more temperate climatic zones, detailed field assessments are needed to ascertain the impact of insecticides in arid regions where locust control was undertaken.

In 1989, AID/Rabat asked DWRC to conduct a two-phase cooperative project with the Government of Morocco's Ministry of Agriculture (MOA) to (1) train Moroccan scientists in the concepts and methods of ecotoxicological studies and (2) conduct studies of the environmental effects of malathion and dichlorvos, the two principal insecticides that had been used in Morocco's locust control campaigns. During 1990, DWRC conducted five training sessions for Moroccan scientists in ecotoxicological methodology. Procedures for evaluating the environmental effects of pesticides were then used by Moroccan and DWRC scientists during a 5-week field study early in 1992 to determine wildlife effects from applications of malathion and dichlorvos to experimental plots. This Project will end in June 1992.

## Objectives

A. Conduct a series of short training courses for Moroccan biologists on methods used in toxicological studies. Training focused on the following agenda:

   1. Introduction to the history, concepts, and conduct of ecotoxicological studies

   2. Chemical analysis for organophosphate insecticide residues in environmental samples

   3. Cholinesterase analysis of brain tissue from animals to determine the intensity of their exposure to organophosphate insecticides

4. Radiotelemetry techniques used in determining lethal, sublethal, and behavioral effects of insecticides on wildlife

5. Field techniques for study of insecticide effects on numbers, food habits, reproduction, and behavior of birds and mammals

6. Field techniques for study of insecticide effects on selected arthropods (foods of birds and mammals, honey bees, as well as the predators and parasites of locusts and grasshoppers)

7. Training on experimental design of studies and statistical analyses of data

B. Conduct research during the rainy season (time of highest biological activity and diversity) to evaluate effects of malathion and dichlorvos applications to experimental plots on birds, mammals, and insects, and also, to assess contamination of the environment.

A field training facility was established near Aït Baha, Morocco.

Argon forests are common in southwestern Morocco and are heavily grazed by goats and sheep.

**Technical Assistance from DWRC**

Drs. Richard Bruggers and James Keith, Study Director of the Morocco Project, traveled to Morocco from December 2 to 8, 1989, and November 27 to December 16, 1989, respectively, to work with AID/Rabat and MOA personnel to implement this new PASA for research and training of Moroccan scientists on evaluating the impact of locust control sprays on the environment and nontarget wildlife. The group resolved details concerned with the training sessions, proposed research, budgets, project documents, procurement of supplies and equipment for the first training session, and plans to hire a resident coordinator. Mr. John McConnell, a former Peace Corps volunteer in Morocco, was hired to serve as DWRC's Logistics Coordinator. He arrived at the Morocco Locust Control Center in Aït Melloul during May 1990.

Dr. Keith traveled to Morocco between May 7 and 26, 1990, to select field areas for training and to provide an introductory training session in Rabat. Dr. Keith and Mr. McConnell met with Mr. Joe Kitts, Locust Coordinator, AID/Rabat, and Government of Morocco personnel in Rabat, Casablanca, and Agadir to review project plans and developments. They also met with Commandant Moha Layid, Deputy Director of Locust Control; Mr. Abdelaziz Arifi, Director, Plant Protection Department; Mr. Thymi Ben Halima, Director, National Center for Locust Control; and other MOA personnel. Following an aerial survey of potential training sites, an area was selected near Aït Baha, about 45 km south of Agadir, and arrangements were made for establishing a camp nearby.

## Training Sessions

Eight consultants conducted five training sessions during 1990. Project teams were organized with the understanding that training and research activities would be open to all participants, regardless of their primary team assignments. The Moroccan scientists who attended the different training sessions are listed in Table 1.

Twenty-three Moroccans participated in the first training session, held in Rabat on May 21 and 22, 1990. Topics included the science of pesticide-wildlife ecology, history of pesticide-wildlife investigations, review of organophosphate effects, residues (collection of samples, analysis, and interpretation), measurement of cholinesterase (concepts, methods, and interpretation), and laboratory dissection procedures.

Dr. John Gillis, Environmental Protection Agency (EPA) Chemist, was in Morocco between May 21 and June 2, 1990, to train 9 Moroccan chemists in chemical methods for research to evaluate the impact of locust control sprays on the environment. He evaluated research capabilities of the equipment and facilities at the Ministry's chemistry laboratory in Casablanca where insecticide residue analyses are conducted. Dr. Gillis also visited the training site to collect representative soil and vegetation samples for training chemists in analytical methodology and to discuss chemistry aspects of this research and other pesticide-related topics with Mr. Kitts.

Messrs. Lawrence Kolz, Electronics Engineer, and Robert Phillips, Wildlife Biologist, traveled from DWRC to Morocco between June 17 and July 2, 1990, to provide both laboratory and field training to 15 Moroccan scientists in the use of radiotelemetry in ecotoxicological studies and specific techniques used to capture and attach radio transmitters to birds and mammals. During this training the scientists followed radio-equipped animals to determine their responses to pesticide applications.

Between September 30 and October 23, 1990, Dr. James Keith, Mr. Keith LaVoie, Dr. Michael Avery, DWRC's Field Station Leader in Gainesville, Florida, and Dr. Patricia Matteson, Entomologist from the Consortium for International Crop Protection, traveled to Morocco to provide training to 14 Moroccan scientists in field methods for determining the biology and relative numbers of birds, mammals, and beneficial insects in the study areas. Techniques for identifying, counting, and capturing vertebrates and invertebrates were demonstrated as well as dissection methods to prepare study skins, examine for food habits, and remove brains for cholinesterase analysis. Dr. Matteson covered training and research on the effect of insecticides on selected insects (foods of vertebrates, bees, and predators and parasites of grasshoppers and locusts).

Between December 7 and 18, 1990, Dr. Richard Engeman, DWRC Statistician, provided training at the MOA Center in Aït Melloul in experimental design as well as statistical concepts and methods for 19 Moroccan scientists and administrators planning to be involved in the upcoming field study. During this training, the preliminary research designs for the bird, rodent, and insect sampling were reviewed and evaluated.

### Research Planning

Between December 1 and 14, 1990, Dr. Keith returned to Morocco to assist in selecting a study area for conducting the research experiment with malathion and dichlorvos and to discuss final plans for the study with officials from the Government of Morocco. A 10- x 12-km area, suitable for the study site, was found near Guelmim. The area had gently rolling hills that were covered by a fairly uniform stand of shrubs, dominated by a 3-foot tall species of euphorbia. The shrub stand was sufficiently open to permit easy walking. Grasses and forbs were sparsely present in the rocky soil, but they would increase with the rains during November through January.

The experiment was originally planned for February and March 1991. Due to travel restrictions created by the Persian Gulf crisis, the study was rescheduled for early 1992 when teams of DWRC scientists cooperated with Moroccan biologists in the evaluation of malathion (750 g/ha) and dichlorvos (200 g/ha) applications to large experimental plots (3.0 $km^2$) in the desert of southern Morocco (study teams are listed in Table 2). Nine plots were used to provide three replications of three treatments (malathion, dichlorvos, and control), as indicated in Figures 6 and 7. ULV applications of insecticides were made from helicopters by Moroccan military pilots who had conducted operational control programs in 1986-1988.

Pretreatment and posttreatment data were collected during the 3 weeks immediately before and after the insecticide applications to provide information to assess the insecticide effects. Objectives of this study included the following:

1. Determine the abundance of birds, mammals, and selected insects.

2. Conduct searches to count carcasses of dead and debilitated birds, mammals, and insects.

3. Use radiotelemetry to evaluate movements, behavior, and mortality of birds and mammals related to treatments.

4. Assess treatment effects on reproduction in birds and mammals.

5. Assess treatment effects on food habits of birds and mammals.

6. Measure brain cholinesterase inhibition in birds and mammals to document intensity of insecticide exposure in survivors and cause of death in animals found dead.

7. Measure insecticide deposited on treated plots to determine treatment efficiency.

8. Measure levels and persistence of insecticide residues in grasses, levels in dead and dying insects, and levels in foods eaten by dead and dying birds and mammals.

American biologists were responsible for formulating plans and work schedules. American and Moroccan biologists cooperated in the collection, compilation, and analyses of data, and preparation of reports and publications. The Government of Morocco arranged for application of pesticides to plots. A field camp was established near the study area to provide facilities for participants, a cook and camp assistants were hired to provide meals and basic necessities, and drivers were available to carry field researchers to and from study plots.

Participants at the October 1990 field training session on methods to assess the impact of locust sprays on birds, mammals, and insects are shown above.

Table 1. Names of Moroccan participants attending the five training sessions conducted by DWRC during 1990.

| Names | Introduction | Chemistry[a] | Radiotelemetry | Population assessment | Statistics |
|---|---|---|---|---|---|
| Abassi M. | X | | X | | |
| Abidi M. | X | X | | | |
| Akchati A. | X | | | | |
| Alhillali O. | | | X | | |
| Aloui A. | X | | X | X | X |
| Arroub H. | X | | X | | X |
| Baou A. | X | | | | X |
| Benchra M. | X | X | | X | X |
| Ben Ider A. | | | X | | |
| Bouaichi A. | | | | | X |
| Boughdad A. | X | | | | |
| Charhbili M. | X | | X | X | X |
| Dala A. | X | X | | X | X |
| Dliou A. | X | | X | X | X |
| El Addami H. | X | | X | X | X |
| El Fayq A. | X | | X | X | X |
| El Hani A. | X | | X | X | X |
| El Harmouchi A. | X | | | | |
| El Ismaili A. | X | | X | X | X |
| Ghaout S. | X | | | X | X |
| Id Messaoud B. | X | | X | X | X |
| Lagnaoui S. | | | | | X |
| Mouhim A. | X | | X | X | X |
| Ouzaouit A. | X | | X | X | X |
| Sahli S. | X | | X | X | X |
| Salah Bennani A. | X | | | | |
| Tarhy M. | X | X | | | X |

[a] Five additional participants also attended the chemistry training session. They were Mr. Behazzouz, Mrs. Dinari, and Ms. Mana from Casablanca; and Mr. Bennis and Mrs. Semmah from Rabat.

Table 2. Research teams for experiment.

| Subjects | Persons responsible for study | |
|---|---|---|
| Insects | P. Matteson[1] | A. Baou<br>A. El Fayq<br>A. El Bakkouri<br>S. Ghaout<br>A. Mouhim<br>S. Sahil |
| Birds | R. Bruggers<br>J. Heisterberg[2] | A. Aloui<br>A. Dliou<br>H. El Addami<br>A. El Hani |
| Mammals | R. Curnow<br>L. Fiedler | H. Arroub<br>A. Ouzaouit<br>B. Id Messaoud<br>M. Charhbili |
| Radiotelemetry | J. Bourassa<br>P. Hegdal[3]<br>R. Johnson<br>R. Phillips | O. Alhillali<br>A. Ben Ider<br>M. Ramzi |
| Cholinesterase/ residues | J. Keith[4]<br>J. Gillis[5] | M. Akchati<br>A. Daia<br>M. Benchra<br>M. Tarhy |
| Computers/data entry | R. Engeman | All participants as scheduled |
| Deposits | J. Keith | S. Lagnaoui<br>A. Afrass |
| Searchers | American teams | |

[1] Entomologist, Consortium for International Crop Protection.

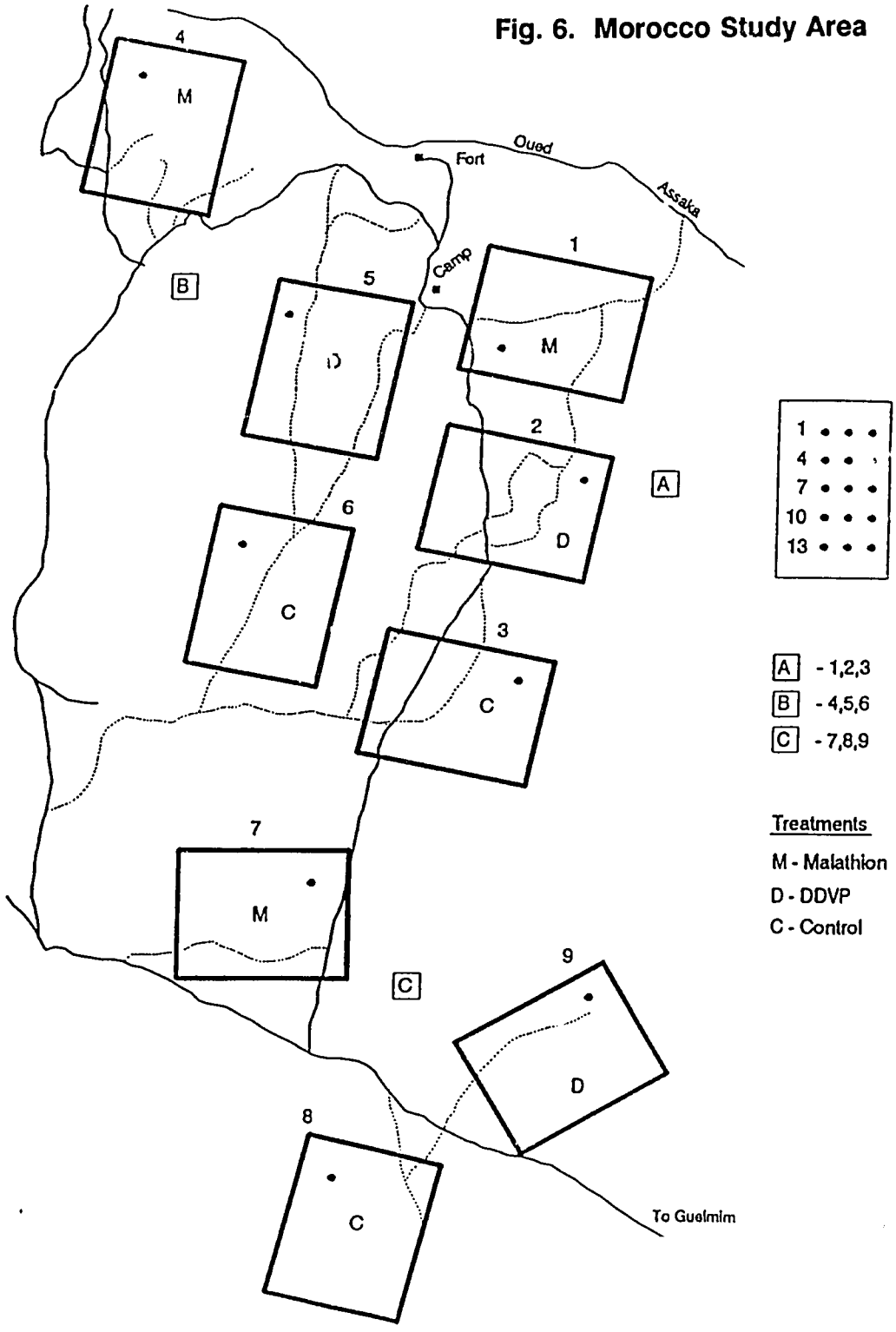
[2] State Director, ADC, Raleigh, North Carolina.

[3] Former DWRC Wildlife Biologist.

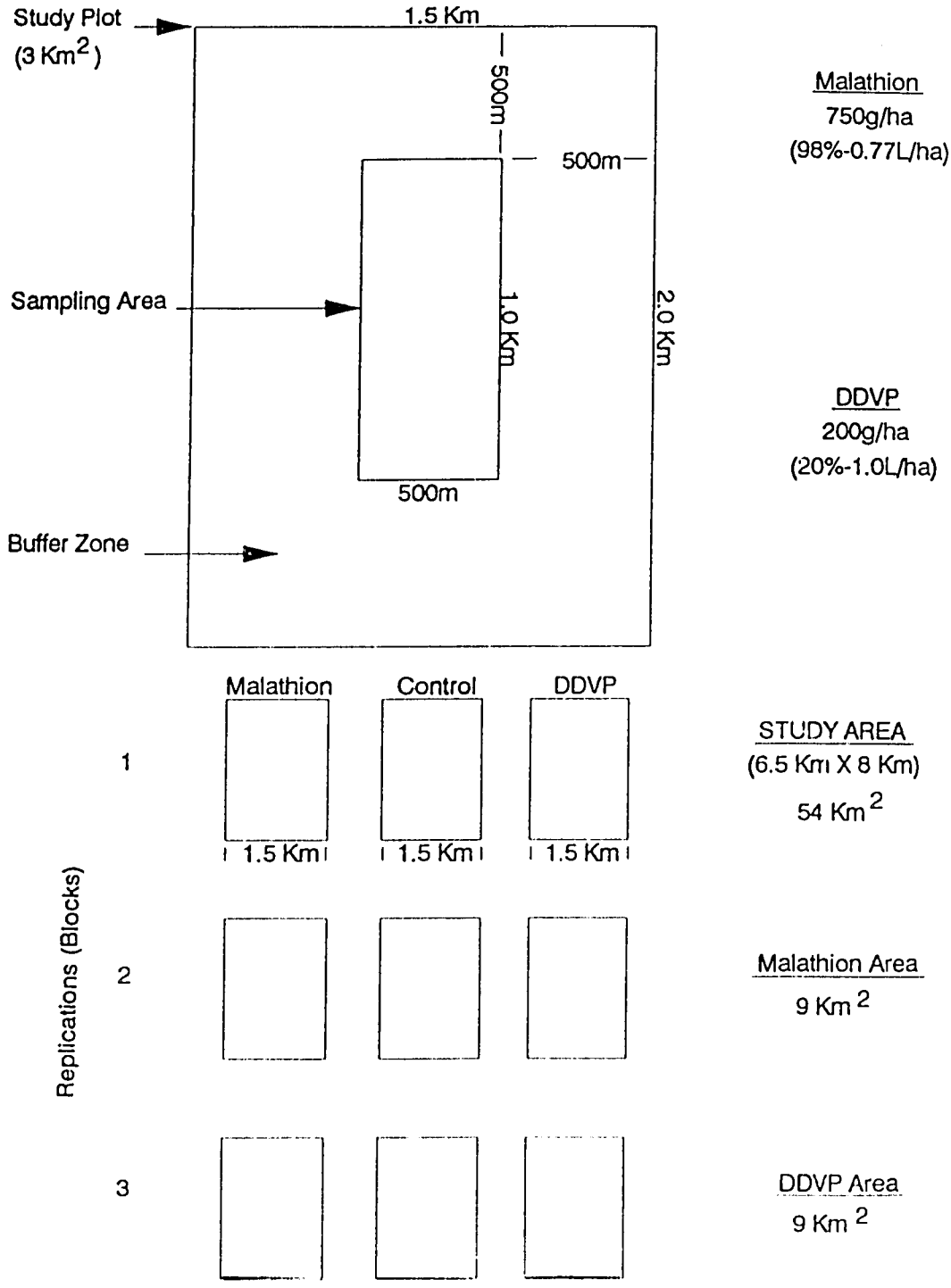
[4] Study Director, Morocco Locust Control Project.

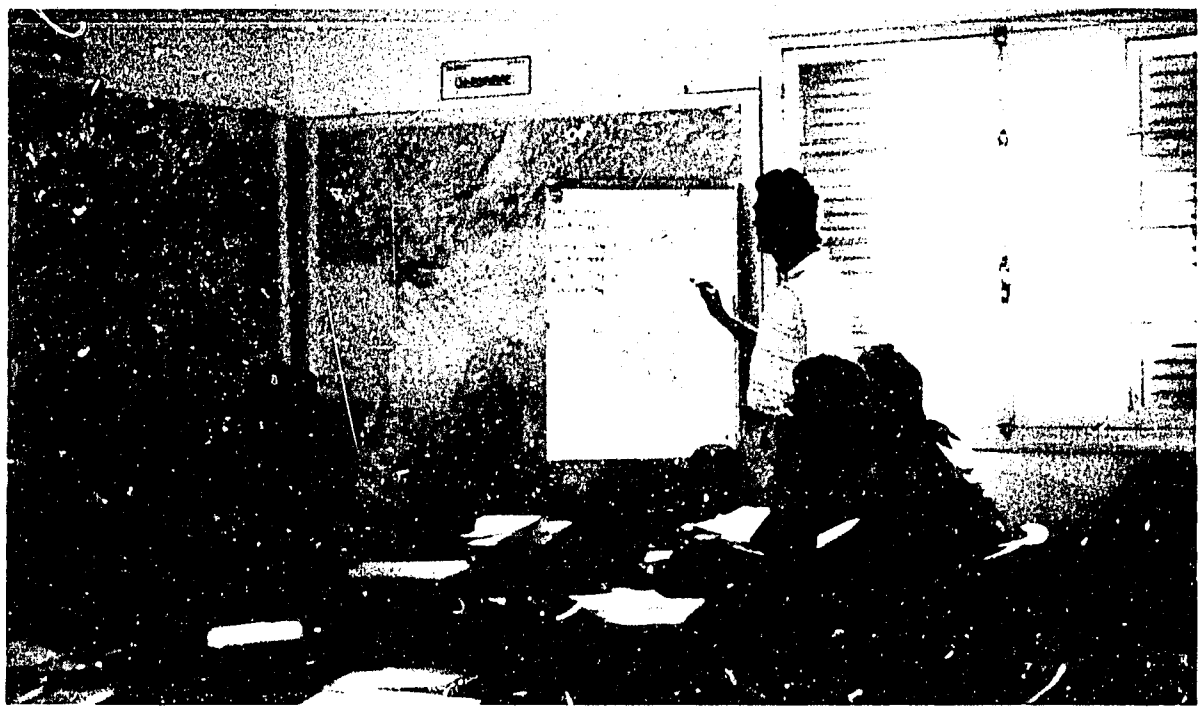
[5] Chemist, EPA.

## Fig. 6. Morocco Study Area



## Fig. 7. Plot Layout



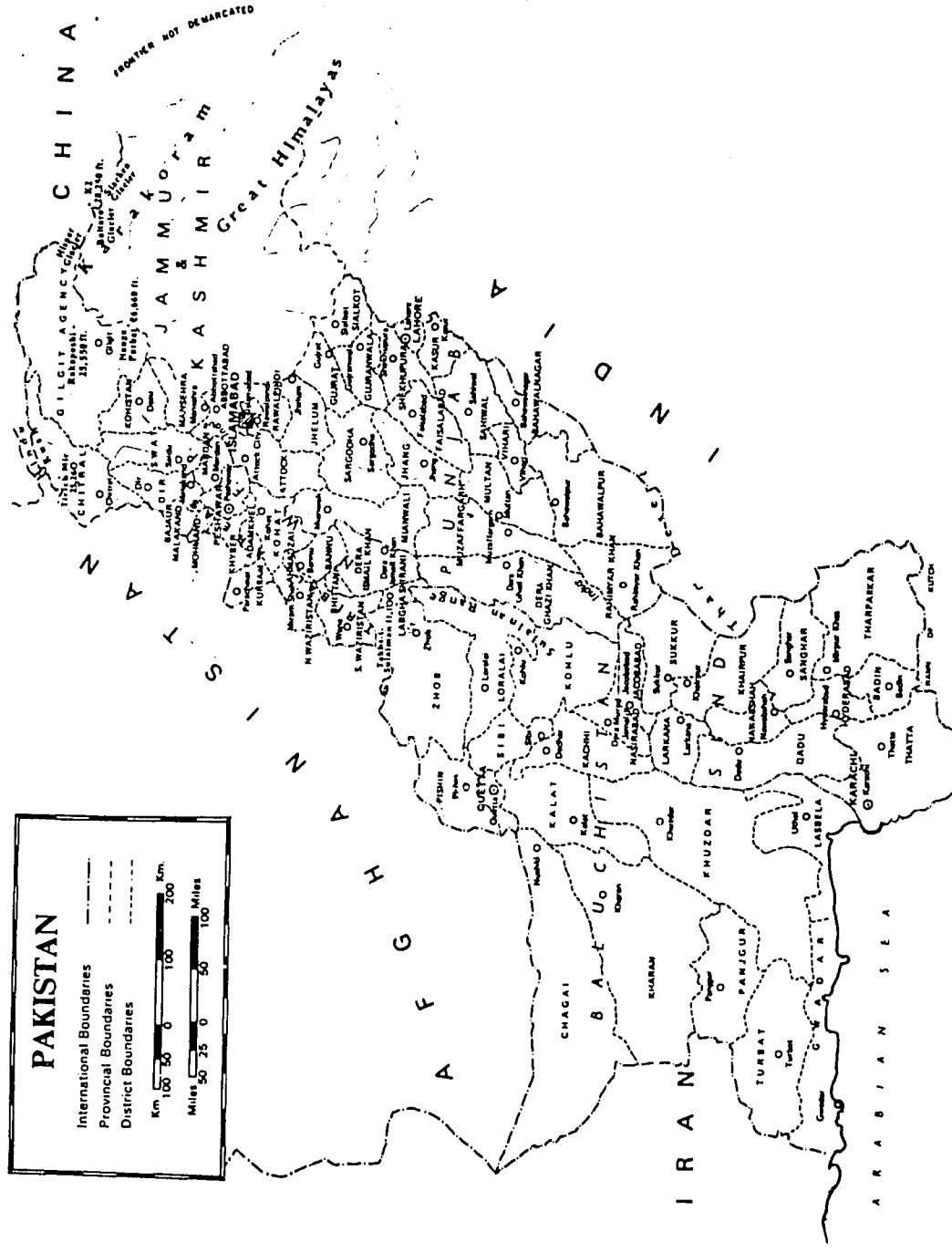


Training lectures and discussions were also held at the Morocco Locust Control Center in Aït Melloul.

A DWRC trainer demonstrates trapping techniques used in mammalian population assessment.

An entomologist helps mammalogists and ornithologists identify food items from the stomachs of mammals and birds.

Moroccan mammalogists prepare study skins of rodents captured in the Argon forests.

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# PAKISTAN

## Introduction

The Vertebrate Pest Control Project (VPCP) in Pakistan was initiated during late 1985 under a USAID mission-sponsored agreement with USDA/DWRC. In January 1986, the VPCP, a subcomponent project under the USAID Food Security Management Project, began occupying its laboratory and office quarters provided by the Pakistan Agricultural Research Council (PARC) and the National Agricultural Research Centre (NARC). Mr. Joe Brooks served as Project Leader in Pakistan between November 1, 1985, and June 30, 1990. DWRC provided technical assistance and back-stopping support to this Project until it ended on June 30, 1991. The overall objectives of the Project included the following:

1. Increase the available food supply.

2. Appraise the nature and magnitude of stored grain losses and agricultural losses caused by vertebrate pests.

3. Develop integrated control programs for important vertebrate pest problems in agriculture and grain storage facilities.

4. Coordinate activities with other international organizations.

5. Develop indigenous capabilities.

6. Institutionalize in-country research and control programs in vertebrate pest management.

## Major Vertebrate Pest Control Project Accomplishments

Between 1985 and 1991, DWRC provided or organized 14 short-term technical assistance, training, and Project planning consultancies. The Project can claim many notable achievements. It has (a) strengthened research and operational vertebrate pest management (VPM) programs within the Government of Pakistan; (b) developed and implemented a control strategy to protect wheat and rice from rodent damage; (c) transferred a developed rodent control technology to farmers in the Gujrat wheat and rice growing area; (d) advanced new knowledge on the biology and behavior of wild boar in Pakistan agriculture, and implemented studies to evaluate methods to control wild boar; (e) established a vertebrate pest research program at the University of Faisalabad, from which 44 Pakistanis have received postgraduate degrees; (f) provided VPM training directly to over 1,300 persons from the public and private sectors; and (g) prepared and produced 28 technical reports, 6 information brochures, a VPM training manual, 15 published articles, and numerous training aids, both written and audiovisual.

Some selected VPCP accomplishments during FY-90 and FY-91 follow:

1. Completed preharvest vertebrate pest damage assessments in wheat, rice, sugarcane, maize, and groundnut fields in 1986, 1989, 1990, and 1991. Damage to wheat in the Gujrat District varied from 3.3% cut tillers in 1989 to 8.4% in 1991.

2. Sponsored a 3-year research study of farm and village stored food losses under a cooperative research agreement with the University of Agriculture, Faisalabad. Rodent populations in farm and village structures were estimated to consume and contaminate 30 kg of commodities annually per farm or village family.

3. Completed surveys at 349 provincial grain storage structures, 25 outdoor grain storage depots, and 52 Pakistan Agricultural Storage and Services Corporation (PASSCO) structures in the four provinces (Balochistan, North-West Frontier, Punjab, and Sind). Grain losses due to vertebrate pests were low (0.1-0.3%). Better structural maintenance and simple good housekeeping practices were recommended to reduce these minor losses.

4. Estimated rodent populations through trapping and activity indices at four large city wholesale commodity markets and at 13 other smaller city markets in Punjab Province. Losses due to rodent consumption and contamination of commodities were estimated at 0.2-0.5% of 1.25 million metric tons.

5. Conducted laboratory studies on the comparative toxicity of three anticoagulants to the roof rat (*Rattus rattus*).

6. Completed a field and laboratory study of the reproductive biology and population structure of *R. rattus* from the Rawalpindi grain market.

7. Studied the food habits of the lesser bandicoot rat (*Bandicota bengalensis*) captured from wheat and rice fields.

8. Conducted a field and laboratory study of the reproduction, diet, and hormone levels in *B. bengalensis* on the NARC Campus. This research led to a M.Phil. Degree for one counterpart scientific officer.

9. Completed cooperative research studies on the Eurasian wild boar (*Sus scrofa*) with the Principal Investigator, Department of Agricultural Entomology, University of Agriculture, Faisalabad.

**Large-scale Rodent Control Demonstration in Gujrat**

A large-scale control demonstration in a 2,200-ha wheat and rice growing area near Kunjah in the Gujrat District was continued through five crop cycles between 1989 and 1991.

During the rice harvest in October 1989, it was found that rodent damage to rice tillers was only 1.3%. Consequently, very few farmers (13 of 103) bought and used the readymade baits. Training was given to 91 individuals, and 450 posters were placed in 10 villages. After the paddy harvest, of 103 farmers interviewed, only 45 farmers were aware of the readymade baits (37 learned of the them from the posters).

During the following wheat season, rodent damage to wheat increased from 0.8% in early March 1990 to 2.8% in April and 6.1% at harvest in early May. This compared to 3.3% damage at harvest in May 1989. From 120 farmers interviewed, 72 farmers were aware of the readymade baits, and baits were used by only 24 farmers. Thus, in three crop cycles, farmer awareness of the readymade baits had increased from 33% to 60%, while use of readymade baits only increased from 10% to 20% (Table 3).

Table 3. Awareness and use of readymade baits by Gujrat farmers in three crop seasons.

| Crop/year | Crop damage % | Farmers aware of readymade baits % | (n) | Farmers using readymade baits % |
|---|---|---|---|---|
| Wheat 89 | 3.3% | 33% | (111) | 10% |
| Rice 89 | 1.3% | 44% | (103) | 13% |
| Wheat 90 | 6.1% | 60% | (120) | 20% |

A new strategy for transferring developed technology was then adopted. Sixty cooperating farmers from five villages in the Kunjah area were trained in different methods of rodent control and were supplied with readymade baits, both acute (zinc phosphide) and chronic (brodifacoum). They applied these baits to rice fields and other crops from mid-July 1990 through August. Meanwhile, the other five villages in the Kunjah area served as untreated references. Rodent damage to rice was minimal, even in late September, and was seen only in a few rice fields. This may have been due to heavy monsoon rains during August and September. Rodents were still burrowing--but only on the bunds, not in field interiors. The sample that was trapped in August contained 15 female lesser bandicoot rats, of which 11 were visibly pregnant and 3 others were in the earliest stages of pregnancy, as judged from their swollen uteri. Project personnel later found that cooperating farmers had been extremely successful in reducing rodent damage to rice, in contrast with damage in fields of the other farmers at the untreated reference villages.

A damage assessment survey was conducted in the Kunjah area between October and December 1990. Ten farmers were selected in 5 of 10 villages, and these farmers were trained in field application of rodenticide baits. In this damage survey, 80 rice fields were then inspected--8 per village. In each of the 5 villages where farmers had been given training and baits, 4 fields of trained farmers and 4 of untrained farmers were surveyed. Damage and undamaged tillers were counted from 25 randomly selected hills

in each field. Burrows present on the bunds and inside the fields were also counted. Of 60 rice fields of the untrained farmers, 203 of 15,184 tillers counted were damaged, i.e., 1.3%. In these 60 rice fields, the lesser bandicoot rat was the only rat present at that time; 315 rat burrows (5.3 per field) were found. In the 20 rice fields of trained farmers, damage was also low (0.1%); only 6 damaged tillers were found out of 4,622 counted, even though the number of burrows was high (7.25 burrows per field). Nonetheless, cooperating farmers had reduced rodent damage by about 90% in contrast to that of the other farmers.

During the February 1991 wheat season, more than 500 bait packets of zinc phosphide bait cakes and loose grain bait of Racumin® were distributed to selected farmers, who presumably implemented control. Although rat burrows were present on field bunds, due to heavy rain it was not possible to visit the wheat fields until March to survey rodent damage. Bait was again distributed to the farmers. For damage assessment, 120 wheat fields were surveyed in 10 villages--12 fields per village. In the 5 villages which had selected farmers, 6 fields of the selected farmers were surveyed in addition to 6 fields of nonselected farmers. Damage was assessed by using a quadrat (50 x 50 cm), taking 10 quadrats in each field along a diagonal transect line. Each quadrat was randomly selected. Damaged and undamaged wheat tillers were counted from each quadrat. Burrows in the field or on the bunds were also counted for each field surveyed. Results showed lowest rodent damage (1.8%) in selected farmers' treated fields and highest damage (4.1%) in nonselected farmers' fields of the same 5 villages. High damage (3.1%) was also recorded in the 5 other villages which had not been supplied with bait. The lesser bandicoot rat was the major rodent pest. In selected farmers' fields, 9.1 rat burrows per field were counted, while 11.3 rat burrows per field were found in other wheat fields.

VPCP scientists checked rice fields for rodent damage in the Gujrat control demonstration area.

Messrs. Munir Asif and Ejaz Ahmad recorded data in the rice fields of Gujrat during the large-scale control demonstration.

### Rodent Control in Sugarcane

In the large-scale control demonstration areas at Kunjah, Gujrat, sugarcane fields were baited after the rice harvest, a time when rodents migrate to surrounding crops, usually sugarcane, as it is the only crop present at the time. To test the theory that controlling rodents in sugarcane would reduce damage to the next wheat crop, sugarcane fields were baited between December 1990 and early 1991, prior to wheat germination in adjacent fields. Bait packets were thrown in each sugarcane field of selected farmers in 5 villages. Results showed that in 12 wheat fields adjacent to treated sugarcane fields, damage was 2.4%. Damage was 2.9% in 5 wheat fields in nontreated areas. Although damage was not significantly reduced in this trial, the concept should be tested on a larger scale.

## Vertebrate Pest Problems in Household Storage

Vertebrate pest problems were surveyed in 60 village houses in 3 villages under Farming Systems Research (FSR) in the Fateh Jhang area. Most of the storage structures (82%) were mud-plastered: only a few (18%) were made of concrete and cement. The majority of the farmers (95%) used bag storage, while 5% had bulk storage in mud or metal bins. Wheat was the major commodity stored--at an average of 674 kg/house in 54 houses.

Vertebrate pests were noted in approximately 97% (58/60) of the structures. House mice (*Mus musculus*) were found in 54 structures; roof rats (*R. rattus*) in 32; and house sparrows (*Passer domesticus*) in 8. The average infestation level of rodents was graded as medium; only 9 structures were marked as severe. The major evidence of vertebrate pests was fecal droppings.

The studies of Mr. Mushtaq-ul-Hassan, a Ph.D. student at the Department of Zoology, University of Agriculture, Faisalabad, provide some indication of the amount of stored food losses that may occur in farm and village structures. Over a 3-year period, Mr. Mushtaq trapped small mammals annually from 110 structures in 12 villages randomly selected in the Faisalabad District. He captured four species: *R. rattus*, *M. musculus*, the Indian gerbil (*Tatera indica*), and the musk shrew (*Suncus murinus*). Roof rats comprised 73% of the 2,029 animals captured, while house mice were 14% of the collection. The Indian gerbil and musk shrew each accounted for 6.5%. Based upon linear regression population estimates of the 1988 data, village houses contained 10.3 small mammals/structure; village shops, 33.2; flour mills, 13.0; and farm houses, 17.8.

Analyzing the stomach contents of the animals, Mr. Mushtaq found they had eaten 19 different items. Cereal grains (wheat, maize and rice) constituted approximately 79% of the diet of roof rats from village houses, shops, and flour mills and 63% of the diet of roof rats at farm houses. Oil seeds, legumes, and pulses accounted for another 11%. An average density per structure (all kinds) was 15 animals, and roof rats accounted for 11 of these. The average amount of food consumed nightly per structure amounted to 141 g, of which 90% was cereals, oil seeds, or legumes. This calculates to a loss of 127 g nightly, or 46 kg per annum. Losses due to house mice could add another few kilograms per year; thus the average village or farm household could expect an annual loss of 50 kg of stored commodities due to rodent consumption. Another 100 kg of commodities would probably be spoiled by wastage and contamination from rodent urine, feces, and hairs.

## Comparative Rodenticide Field Trials in Groundnut

Five sites in groundnut fields near Dhudial (Chakwal District) were selected for field testing of three rodenticides. Rats infesting the groundnut fields were mainly bandicoots and short-tailed mole rats (*N. indica*), but there were also a few Indian gerbils (*T. indica*). One site was treated with 2% zinc phosphide (fast-acting) grain baits, which were placed near the burrow openings. Two other sites were treated with anticoagulant (slow-acting) baits: coumatetralyl (Racumin) and flocoumafen, at concentrations of 0.0375% and 0.005%, respectively. The first baits were placed during the last week of August 1990, followed by the second and third baitings. The remaining two sites were left untreated as control plots or reference sites. Efficacy was evaluated from the decrease in burrowing activity of the three rat species. The number of burrows treated with rodenticides in groundnut fields near Dhudial are summarized in Table 4.

Table 4. Burrows treated with rodenticides in groundnut fields near Dhudial in 1990.

| Site | Acres | Treatment | No. burrows treated | | |
|---|---|---|---|---|---|
| | | | 1st | 2nd | 3rd |
| 1 | 20 | Zinc phosphide (2%) | 243* | 233* | 320 |
| Ref 1 | 11 | Reference | 96** | - | - |
| 2 | 21 | Flocoumafen (0.005%) | 178 | 50 | 28 |
| 3 | 20 | Coumatetralyl (0.0375%) | 285 | 22 | 18 |
| Ref 2 | 12 | Reference | 202** | - | - |

* Heavy rains after each baiting.
** Not treated.

The third treatment was made 2 weeks before harvest in the groundnut crop in early November 1990. Before collecting yield data, a final count of active burrows/ha was made on all treated and reference fields. To take yield data, 4-6 fields were randomly selected, and each field was divided into 4 quadrats (2 x 2 m) along a diagonal transect line. Each quadrat (2 on each side of the transect line) was picked by walking a certain number of random steps. All plants were removed, and nuts were hand-picked from each quadrat. Yield/ha was calculated at 12% moisture weight of nuts. The yield data could be obtained in only three sites (Table 5), as the zinc phosphide and its reference areas had to be abandoned due to flooding. The percent of increase in yield after baiting with coumatetralyl and flocoumafen was 58.4% and 59.4% respectively.

Table 5. Groundnut yields from treated plots in Pakistan during November 1990.

| Treatment | Area treated (ha) | Yield/ha (kg)* | % yield increase |
|---|---|---|---|
| Coumatetralyl (0.037%) | 8 | 490 | 58.4 |
| Flocoumafen (0.005%) | 9 | 483 | 59.4 |
| Reference 2 | 5 | 303 | - |

* Calculated @ 12% moisture weight.

## Food Habits Studies

Small mammals were trapped in early 1990 from wheat fields in the Kunjah area of the Gujrat District. Their stomach contents were analyzed to determine their diet. Of the six species captured, the lesser bandicoot rats comprised 80% of the collection and Indian gerbils, 10%. In March, lesser bandicoot rats were feeding on stems and leaves of wheat as well as stems and seeds of *Convolvulus*, *Cynodon*, *Cyperus*, and *Ranunculus*. Wheat grains became increasingly important in April and May as weeds and grasses declined. Indian gerbils fed heavily on *Convolvulus* in March, April, and May; wheat was approximately one-half their diet in May.

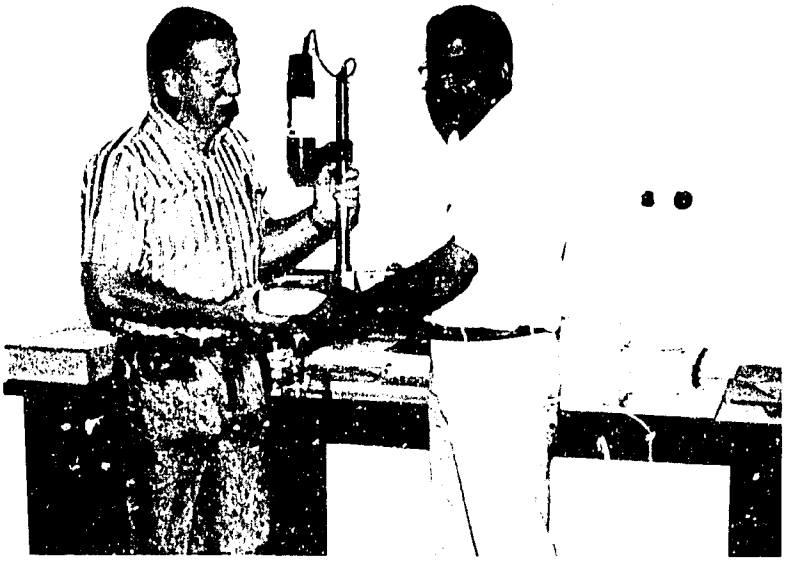
Lesser bandicoot rats (*B. bengalensis*) were also trapped at Kunjah during the rice season. Seeds and leaves of several grasses (*Echinochloa*, *Dactyloctenium*, and *Setaria*) were the most important dietary items in August when rice plants were at the flowering stage. Sorghum was a minor item, since some rats were captured from sorghum fields adjacent to rice fields. In October, however, the major diet of the lesser bandicoot rats had shifted to rice grains and stems (86.6%), while seeds and stems of the grasses had decreased in importance.

The VPCP also completed a preliminary analysis of the diet of Eurasian wild boar (*Sus scrofa*). Stomach samples taken from 393 animals in Pakistani croplands revealed that plant materials (both cultivated and noncultivated) comprised 96.9% of the total mass; animal matter (2.5%) and mud (0.6%) made up the rest. Wheat (both leaves and grain) was the dominant dietary item; it comprised 54.7% of the total mass and occurred in 262 stomachs. Sugarcane (8.6%, 64 stomachs), rice (3.6%, 20 stomachs), and mesquite (*Prosopis juliflora*, 7.2%, 43 stomachs) were also found. Wheat first appeared as leaves in the diet in December. By April, wheat grain was the major dietary item, continuing in importance through July. Rice was first present in the diet of the wild boar during August, the major food item in October, and off the menu by December. Sugarcane was an important dietary item from December through March. The wild boar heavily consumed mesquite during June and July following the wheat harvest. These findings illustrate the importance of the wild boar as a forager of cultivated crops in the irrigated croplands of central Punjab.

## Wild Boar Biology and Control

The Eurasian wild boar (*Sus scrofa*) is a native of Pakistan and widely distributed throughout most of the lower elevations. It is particularly a pest of wheat and sugarcane and is regarded as the second most important vertebrate pest of agriculture in Pakistan.

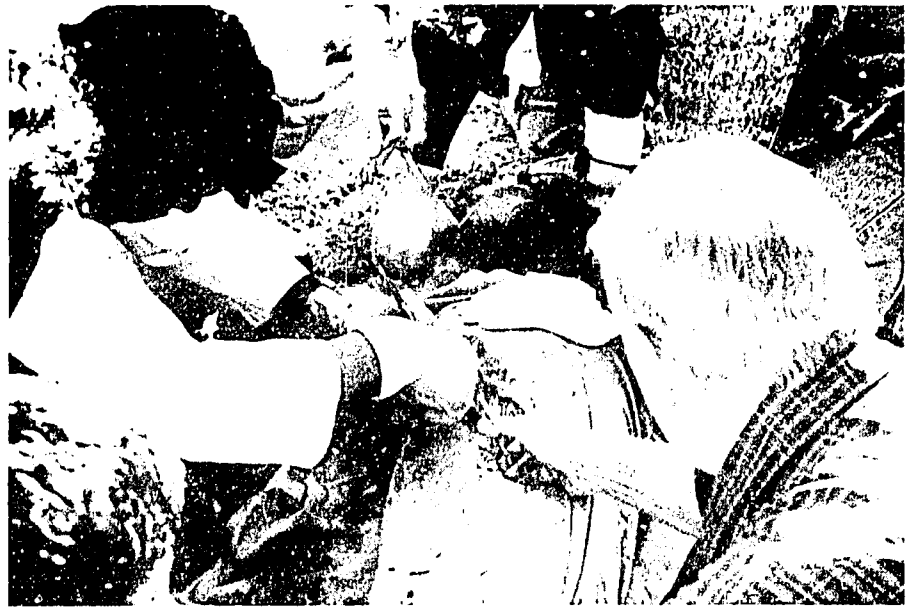
A cooperative research study on the biology and control of the wild boar in agricultural areas was undertaken with the University of Agriculture, Faisalabad. The objectives of the study were to describe the biology and behavior of the wild boar and develop simple, safe, effective, and inexpensive methods of reducing their damage to crops. Between March 1987 and July 1990, the research cooperator collected 519 Eurasian



Mr. Joe Brooks, on behalf of DWRC, presented a grinder for food habits studies to Dr. Mirza Baig with the Department of Zoology, University of Agriculture, Faisalabad.

wild boar from crop and noncrop areas of central Punjab, Pakistan. Besides body measurements, the left or right lower jaw, eye lenses, reproductive organs, and stomach contents were taken at necropsy and preserved in 5% formalin for further studies. Wild boar in Pakistan are seasonal breeders. They mate in late December or January and farrow in March through September; peak births occur in May. Both males and females are reproductively mature by 5-7 months of age. Litter sizes averaged 5.65 per female over the 3-year study. Age composition of the collected sample suggested that only about 50% of the animals survived after 1 year, 25% were 1-2 years old, and about 25% were 3-6 years old, indicating a rather rapid population turnover. Critical periods (times in the annual population cycle when the animals are most vulnerable to control methods) are May/June (near the end of the breeding season and end of the wheat harvest) and again in November/December (at the start of breeding and when the sugarcane harvest is underway).

For effective management of wild boar populations, information is needed about their daily and seasonal movement patterns in response to crop changes and habitat preferences. This will help to better understand their social behavior, group size, and foraging range. To observe the movement patterns of wild boar, radiotelemetry studies were initiated in September 1990. Five wild boar were captured in croplands and marshy areas in the Faisalabad District, fitted with radio-collars, and released. Movements were monitored for 7 months. Two radio-tagged females ranged over about 2 $km^2$ in croplands in the Faisalabad District; they used sugarcane fields mainly as resting areas. One large male, living in a mixed forested and cropland area, used only about 1 $km^2$ in the forest as his home range. Two females, living in a mixture of marshy



DWRC scientists and Pakistani veterinarians surgically implanted a radio transmitter into the abdominal cavity of a wild boar in Fateh Jhang.

Mr. Ejaz Ahmad used radiotelemetry to track some wild boar in the Fateh Jhang area.

grassland and field crops, showed the most extensive movements: one female ranged over about 4 $km^2$ between November 1990 and March 1991, while the other female ranged over an area covering 8 to 10 $km^2$ and frequently moved as much as 5 to 6 km nightly while foraging. Humans and dogs killed three of the five animals during the study.

In Fateh Jhang, one young male wild boar had a radio transmitter surgically implanted into his abdominal cavity and was released 2 days later. His signal was followed for 6 months after release. Two other wild boar, one male and one female, were instrumented with regular radio transmitters attached to neck and girth collars. These animals were followed until death of the male and loss of the radio by the female, respectively. These three animals, which had been released into mixed mesquite, acacia forest, and croplands near Fateh Jhang, had small ranges of 3-6 $km^2$. One male was found dead 5.5 km from his release point.

A 10-day field test for wild boar control was conducted in May 1991 at Kheri Murat near Fateh Jhang. Apple-scented and unscented pelleted baits (without poison) were placed in furrows in the soil to determine acceptance by boars. These baits were prepared by the DWPC Chemical Development/Registration Section. There was a lag of about a week before wild boar began to root up the pelleted baits, but they did consume bait from 5 of the 9 stations. Essentially, no difference in consumption between scented and unscented baits occurred. Rains during the field trial showed the need to waterproof the pelleted baits, as moldiness was apparent after the baits had been in the soil for a week. Porcupines visited a few of the sites and consumed some of the exposed baits, suggesting that research into a more selective delivery system is needed. No signs of jackals were found. Much additional research is needed to develop selective boar control techniques for use in areas where boar are known to be significant pests.

## Porcupine and Jackal Control at Pakistan Air Force Base, Sargodha

At the request from Pakistan Air Force (PAF) authorities, a control trial for jackals and porcupine was initiated at PAF Base, Sargodha. Sargodha Air Base is enclosed by a boundary wall. About 5 years ago, after construction of the boundary wall, the Flight Safety Division staff conducted control operations against wild boar which proved to be effective, as no additional boar have been found there. However, the jackal population inside the boundary increased with the passage of time and began posing a hazard to aircraft. Control operations were carried out November 2-10, 1990, following a survey which indicated that porcupines and jackals were the main vertebrate pests. On the basis of footprints and burrow counts, it was estimated that about 30-40 jackals and 60-80 porcupines were living in this Air Base. For control measures, an acute toxicant sodium fluoroacetate, also known as Compound 1080 (0.03%), was used. Baiting was done in the form of bait balls using wheat flour and brown sugar as bait base. Prebaiting was done with plain bait for 2 nights, and then poison baits were placed inside the porcupine burrows or near the tracks for 4 nights. Although there appeared to be no other nontarget animals, as a precautionary measure, baits were placed after

sunset and uneaten bait balls were picked up the next morning before sunrise. After 4 days' baiting, all the porcupine burrows were found inactive and about a 95% reduction in jackal population was noted. During this operation, six staff members of the Flight Safety Division at the air base were trained in control measures. Their training included preparation and application of baits for control of vertebrate pests and various safety precautions in handling of poisons.

## Institutionalization of Vertebrate Pest Management at NARC

Institutionalization of Vertebrate Pest Management at NARC has been accomplished. The substation of the Vertebrate Pest Control Laboratory (VPCL) at NARC was upgraded to full station status in July 1990, and the VPM program is an integral part of NARC activities. The VPCL/NARC is independent of VPCL/Karachi and is responsible for investigating vertebrate pest problems and their solutions in the Punjab and North-West Frontier Province, while VPCL/Karachi will concentrate activities in Sind and Balochistan.

Vertebrate Pest Management became part of the graduate level curriculum in Pakistan during FY-91. The Department of Zoology, University of Agriculture, Faisalabad, initiated a one-semester graduate course in vertebrate pest management and used the "Training Manual on Vertebrate Pest Management," developed by the Project scientists, as its core textbook. The Department of Agricultural Entomology also used this training manual.

## Cooperative Research with Universities

Several graduate students initiated and/or completed studies of vertebrate pest problems under a cooperative research agreement between the Vertebrate Pest Control Project (VPCP) and the University of Agriculture, Faisalabad. Dr. Mirza A. Beg has coordinated this research. Between 1985 and 1991, 44 graduate students received advanced degrees (M.Sc., M.Phil., and Ph.D.) in vertebrate pest management topics. Graduate research during 1990 and 1991 included the following studies:

Akhtar, Shamim. 1991. Food habits of indoor *Mus musculus* populations in rural and urban areas of central Punjab. M.Phil. Thesis, University of Agriculture, Faisalabad.

Akhtar, Tasleem. 1990. Food habits of *Rattus meltada* in a wheat-sugarcane-fodder agroecosystem of Faisalabad. M.Sc. Thesis, University of Agriculture, Faisalabad.

Ali, R. A. 1990. Population density and reproduction of house rats (*Rattus rattus*) living in grain shops and residential houses of Faisalabad city. M.Sc. Thesis, University of Agriculture, Faisalabad.

Ali, S. Z. 1991. Food habits of little owlet (*Athene brama*) in central Punjab. M.Phil. Thesis, University of Agriculture, Faisalabad.

Amir, Riffat. 1990. Food habits of *Tatera indica* in a wheat-sugarcane-fodder agroecosystem of Faisalabad. M.Sc. Thesis, University of Agriculture, Faisalabad.

Butt, Abida. 1990. Food habits of *Bandicota bengalensis* in a wheat-sugarcane-fodder agroecosystem of Faisalabad. M.Sc. Thesis, University of Agriculture, Faisalabad.

Inam, M. 1991. Breeding success in the rose-ringed parakeet in central Punjab. M.Phil. Thesis, University of Agriculture, Faisalabad.

Hassan, R. M. 1990. Inhibiting lesser bandicoot rat populations in a wheat-sugarcane-fodder system of croplands. M.Sc. Thesis, University of Agriculture, Faisalabad.

Hussain, S. Riaz. 1991. Ecology of the short-tailed mole rat (*Nesokia indica*). Ph.D. Thesis, University of Agriculture, Faisalabad.

Kamil, Munazza. 1991. Food habits of *Rattus rattus* in Faisalabad city. M.Phil. Thesis, University of Agriculture, Faisalabad.

Khan, A. A. 1990. Population density and reproduction of house rats (*Rattus rattus*) living in some grocers' shops and sweet shops of Faisalabad city. M.Sc. Thesis, University of Agriculture, Faisalabad.

Mubarik, Samia. 1990. Food habits of *Mus musculus* in a wheat-sugarcane-fodder system of Faisalabad. M.Sc. Thesis, University of Agriculture, Faisalabad.

Mushtaq-ul-Hassan, M. 1991. Distribution, population dynamics, and economic importance of rats and mice in village and farm houses. Ph.D. Thesis, University of Agriculture, Faisalabad.

Rana, Shahnaz A. 1990. Biology and taxonomic status of the little Indian field mouse in Punjab. Ph.D. Thesis, University of Agriculture, Faisalabad.

Saeed, Muhammad. 1990. Inhibiting house mice in a wheat-sugarcane-fodder system of croplands. M.Sc. Thesis, University of Agriculture, Faisalabad.

Shafiqur-Rehman. 1991. An analysis of the crop contents of the house sparrow. M.Phil. Thesis, University of Agriculture, Faisalabad.

Sher, M. K. 1990. A method of inhibiting the soft-furred field rat (*Millardia meltada*) in a wheat-sugarcane-fodder system of croplands. M.Sc. Thesis, University of Agriculture, Faisalabad.

Siddiqi, M.J.I. 1990. Food habits of small Indian mongoose in the agroecosystem of central Punjab. M.Phil. Thesis, University of Agriculture, Faisalabad.

Siddique, M. 1991. Food station transects as a means of indexing porcupine population fluctuations. M.Phil. Thesis, University of Agriculture, Faisalabad.

Ubaidullah, M. 1991. House sparrow damage to cereal crops in central Punjab. M.Phil Thesis, University of Agriculture, Faisalabad.

## Training and Extension

### Pest Management in Grain Storage

The VPCP continued to cooperate with the Kansas State University Storage Technology Development and Transfer (STDT) Project in giving master's training to grain storage personnel. Six master trainers participated in lectures and practical field demonstrations at the STDT training facilities in Lahore for 2 days during October 1989. The STDT has used a grain storage manual, posters, brochures, audio slide sets, and video training cassettes developed by the VPCP to train over 1,500 provincial and PASSCO grain storage personnel.

At the request of the Government of Azad Jammu and Kashmir and the Food and Agriculture Organization (FAO) of the United Nations, VPCP and VPCL staff conducted a 6-day training session on pest management in grain storage for 24 field assistants and attendants during September 1990.

### Porcupine Control

The Integrated Hill Farming Development Project within Azad Jammu and Kashmir has successfully implemented a strategy to control porcupine damage to chir pine seedlings based on suggestions and technology transfer provided by the VPCP. The success of an initial treatment of approximately 50 porcupine dens with the burrow fumigant phosphine gas and the anticoagulant Racumin led to a larger scale, replicated (3 x 500 acres) demonstration in which seedling survival increased from only 13% to a survival rate of 94%.

### Women Involved in Vertebrate Pest Management

The increased involvement of women in on-farm vertebrate pest control is considered to be extremely important to the acceptance and implementation of an overall VPM strategy in developing countries. The VPCP has taken an active role in providing technology transfer of insect and rodent control to women through the FSR locations. During FY-90, 215 women saw videos on the preparation and use of rodenticides, attended actual practical field training in proper application methods, and received readymade bait for beginning control measures.

During FY-91, women continued to take VPM training. Twenty-three rural women in Jinder, Fateh Jhang, attended lectures on rodent biology and their control, viewed a video on rodent control in wheat, and received readymade rodenticidal bait of zinc phosphide. Training was conducted under the FSR Project. Ms. Naheed Mahmood, Senior Scientific Officer, Entomology Research Laboratory, delivered the lectures. Mrs. Mahmood had been trained in various VPM techniques by VPCP staff.

### Training at NARC

Ms. Shamim Akhtar, a graduate student working in the Department of Zoology, University of Agriculture, Faisalabad, received 5 days of in-service training in methods of food habits analysis during December 1989 at the VPCL/NARC.

One hundred fifty-nine farmers and agricultural extension staff in the Islamabad Capital Territory received training on rodent control in wheat in January 1990. This training included lectures, videos, and practical demonstrations.

In March 1990, the VPCP presented a 2-week training course on Vertebrate Pest Management for 19 agricultural officers and teachers at the Training Institute, NARC. Participants received extensive laboratory and field training during this class, viewed several videos, and were given copies of the new 200-page "Training Manual on Vertebrate Pest Management."

The VPCP staff organized a 2-day training course in May 1990 for field staff of the Barani Agricultural Research and Development (BARD) Project at NARC, Islamabad. VPCP personnel provided training in many aspects of management regarding vertebrate pests of groundnuts, including rodents, wild boar, and crested porcupines. Participants attended sessions on how to identify damage by these pests and methods to assess the damage; rodenticides, bait preparation, and bait application methods in groundnut fields; and field demonstrations on bait application and fumigation methods. Later, BARD organized a farmers' field day, whereby the VPCP provided training on rodent control in groundnuts for approximately 125 farmers and extension workers from DAE.

VPCP personnel also have the opportunity for training and career development through the Training Institute at NARC. Messrs. Ejaz Ahmad and Shahid Munir attended a 5-day training course in radiotelemetry during June 1990. This course was presented by Dr. Simon Dowell, World Pheasant Association, United Kingdom, and organized by the World Pheasant Association, Islamabad Capitol Development Authority, and PARC. In May 1990, Mr. Ahmad attended training in advanced video production and editing at the NARC Training Institute; this training was organized by the AID Management of Agricultural Research and Technology Project. During FY-90, Project staff also attended NARC classes in VPM and efficient usage of analytical equipment.

During late 1990, the VPCP prepared a video on rodent control in wheat. This 15-minute film, entitled "Gandum Kay Dushman" (Enemies of Wheat), is in the Urdu language. It shows how to identify rodent damage to wheat by observing cuttings, the

presence of burrows, and hoarding of grain by the lesser bandicoot rat. The film includes demonstrations on conducting rodent control, setting traps, different rodenticidal baits, their application, and fumigation of burrows. This video will be shown to various farmers attending training courses at different sites during the wheat season.

The VPCP annual training course on VPM was held between September 28 and October 10, 1991, at the Training Institute, NARC. Seventeen participants (agricultural extension officers, scientific officers, and grain storage officers) attended lectures on VPM, field and laboratory demonstrations on damage assessment methods, and practical demonstrations on bait preparation and bait application methods for both rodent and wild boar control.

### Open House at NARC

An open house was organized by PARC at NARC from March 2-13, 1991. The purpose of this open house was to show NARC's contribution in agricultural research and to introduce developed technology to people from different walks of life. VPCP also participated in this open house and arranged a display that included different types of bait formulations for control of rats, porcupine, and wild boar. VPCP distributed its various training manuals, brochures, and pamphlets, prepared both in English and Urdu, and they showed videos on rodent control in wheat and rice. This open house was attended by groups of diplomats, senators, members of the Pakistan National Assembly, scientists, journalists, farmers, and students.

### Training in the Villages

Training on rodent control in wheat was the major VPCP activity in early 1991. VPCP personnel conducted eight 1-day training courses in several villages in Islamabad and Chakwal. In Islamabad, 77 farmers received training at Chirah, Rawal, and Bani Gala during January 1991; in Chakwal, 129 farmers and 100 high school students participated in these training courses at Bhean, Umra, Bazeed, Chakral, and Jand during March 1991. The training at Islamabad was jointly organized by the Administration Islamabad Capital Territory and NARC's Transfer Technology Unit, while that at Chakwal was organized by the Farmers Forum, District Council, Chakwal, and the Training Institute, NARC--the Farmers Forum was established by PARC to disseminate the developed technology directly to farmers. Training included discussions on rodent pest problems of wheat, damage patterns, control methods, and a video entitled "Enemies of Wheat" (this film was prepared by VPCP personnel). VPCP staff conducted practical demonstrations of both types of bait preparation (i.e., zinc phosphide cake bait and loose grain Racumin bait), application, and fumigation of burrows; and they distributed readymade rodenticidal bait and a handbook on rodent control to the farmers.

Between 1986 and 1991, over 2,000 individuals (ranging from farmers to research scientists) attended the vertebrate pest control training in the field.

### Training in Azad Jammu and Kashmir

The In-Service Agricultural Training Institute in Azad Jammu and Kashmir (AJK) organized a training course on rice and maize production at Garhi Dopatta. This course was held between March 16 and 21, 1991, for 13 field assistants working in various agricultural departments of AJK. VPCP staff lectured on VPM (one lecture was on vertebrate pest problems of rice and maize crops; the other, on different chemical and nonchemical methods for their control). The VPCP also showed their videos on rodent control in rice and wheat, and they distributed an Urdu booklet on rodent control in different crops.

### Graduate Studies

Mr. Shahid Munir, Scientific Officer with the VPCL/NARC, visited the DWRC from November 25, 1989, to January 5, 1990, to learn techniques to measure the stability of rodenticides under different environmental conditions and evaluate their effects on nontarget animals. While at DWRC, Mr. Munir worked and discussed his research proposal with specialists from the Mammal Control Research Section, Analytical Chemistry Section, and IPRS. Mr. Munir will continue his ecotoxicology studies in a Ph.D. program at the University of Punjab in Lahore.

Mr. Ejaz Ahmad, DWRC counterpart research scientist with the VPCP between 1985 and 1991, has been accepted into graduate school at Colorado State University. He began his graduate studies during the 1991 fall semester in the Department of Fishery and Wildlife Biology. His proposed research topic is "The use of biodegradable microspheres as oral vaccine carriers for rodents." Mr. Ahmad has Master of Science in Biology and Master of Philosophy in Plant Physiology degrees from Quaid-i-Azam University in Islamabad. He also has authored or coauthored about 10 scientific publications and one "Training Manual on Vertebrate Pest Management."

### Technical Assistance from DWRC

Ms. Paige Groninger, Computer Programmer Analyst, visited the VPCP in March 1990 to install SAS and a new version of Lotus 1-2-3. Ms. Groninger also provided assistance and training to the Project Leader and counterpart scientists in the use of these computer programs.

Drs. Richard Bruggers and Michael Fall, Chief, Predator Control Research Section, visited the Project during March 1990 to review Project progress and initiate detailed work plans, objectives, and guidelines for follow-on activities after June 30, 1991. Due to a change in AID Mission priorities, the follow-on activities were not funded.

Mr. Joe Brooks returned to the DWRC on June 1, 1990, at the termination of his assignment as full-time Project Leader in Pakistan. Mr. Brooks, however, again traveled to Pakistan on TDY between August 7 and November 20, 1990, to assist the VPCP in

conducting rodent field trials and continuing wild boar studies. During the final year of the Project, Mr. Brooks provided guidance to Pakistani staff in planning research and training activities and implementing appropriate measures of vertebrate pest management.

Mr. Richard Johnson, DWRC Electronics Technician, visited Pakistan from October 2 to November 2, 1990, to train and/or assist Mr. Brooks and scientists at NARC in (1) trapping wild boar, (2) operating electronic equipment, (3) attaching radiotelemetry collars to the animals and tracking them in the field, and (4) keeping the necessary records before and after releasing an instrumented animal. Mr. Johnson also assisted in surgically implanting a radio transmitter in a wild boar.

Mr. Brooks returned to Pakistan between May 15 and June 29, 1991, to close out DWRC full-time involvement in the VPCP; arrange for transfer of equipment, supplies, and vehicle to the VPCL/NARC; investigate mechanisms for continued short-term coordination and cooperation among the DWRC, VPCL/NARC at Islamabad, and the principal investigators at the University of Agriculture, Faisalabad; and complete the technical and final VPCP reports.

## Introduction

Under the 1967 cooperative program established by the Administrator, U.S. Agency for International Development (USAID), core funds were provided to DWRC by the USAID Bureau of Science and Technology to maintain a group of international vertebrate pest specialists in the International Programs Research Section (IPRS) to implement outreach activities in international vertebrate pest management (VPM). The program goal is to evaluate vertebrate pest situations in Africa, Asia, and Latin America and, when circumstances warrant, develop and implement environmentally acceptable methods to reduce vertebrate pest damage. 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 TDY support for foreign field stations.

2. Conduct cooperative, problem-oriented research at DWRC based upon priorities of field programs.

3. Develop and implement proposals for 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 with international organizations, such as FAO, 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.

**DWRC Information Transfer**

During Fiscal Years 1990 and 1991, IPRS received and responded to 394 requests from 89 countries for information, training, and technical assistance. Reprints and reports totaling 7,947 were provided to scientists and other individuals worldwide (Table 6).

Table 6. Requests to DWRC for assistance between October 1989 and September 1991.

| Type of request or activity | Total No. |
|---|---|
| Information on International Programs | 51 |
| Information or Literature on Research and Crop Protection Methods | 157 |
| Information on Graduate Schools in VPM | 13 |
| Materials/Photographs | 26 |
| TDY's Implemented by or through IPRS in Technical Assistance Research, Training, and Extension | 65 |
| Requests of IPRS for | |
| - Funds | 12 |
| - Research Opportunity | 9 |
| - Training | 31 |
| - Hiring | 21 |
| - Project Development | 9 |
| No. International Visitors | 36 |
| No. Reprints Distributed | 7,519 |
| TOTAL | 7,949 |

Originating countries and regions:

Argentina, Australia, The Bahamas, Bangladesh, Barbados, Belgium, Belize, Bhutan, Botswana, Brazil, Bulgaria, Burkina Faso, Burma, Canada, Cayman Islands, Chad, Chile, China, Colombia, Costa Rica, Cuba, Denmark, Dominican Republic, Germany, Ecuador, Egypt, El Salvador, Equatorial Guinea, Ethiopia, Finland, France, Gambia, Ghana, Guam, Guinea-Bissau, Honduras, India, Indonesia, Iraq, Ireland, Israel, Italy, Ivory Coast, Japan, Kenya, Korea, Latvia, Madagascar, Malaysia, Mali, Marshall Islands, Mexico, Montserrat, Morocco, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Nigeria, Pakistan, Panama, Paraguay, Philippines, Poland, Portugal, Puerto Rico, Senegal, Sierra Leone, Singapore, South Africa, Spain, Sudan, Switzerland, Taiwan, Tanzania, Trinidad, Uganda, United Kingdom, U.S.A., U.S.S.R. (Union of Soviet Socialist Republics), Uruguay, Venezuela, Virgin Islands, West Indies, Republic of Yemen, Yugoslavia, Zambia, and Zimbabwe.

## DWRC Outreach Consultancies

Between October 1989 and September 1991, DWRC staff traveled to Africa, Asia, the Caribbean, and Europe at the request of USAID missions, AID/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 participate in workshops and conferences. TDY activities from DWRC have become an important part of the project, 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-90 and FY-91 involved 1,089 person-days to the following locations:

| | | | |
|---|---|---|---|
| Argentina | Grand Cayman | Malaysia | Republic of Yemen |
| Bahamas, The | Guam | Morocco | Saint Lucia |
| Bangladesh | Guinea-Bissau | Pakistan | Senegal |
| Barbados | Indonesia | Philippines | Uruguay |
| Chad | Italy | Puerto Rico | |

Travel dates, persons involved, locations visited, and the purpose of each trip are outlined briefly in Table 7. Detailed information is contained in individual trip reports on file at DWRC/IPRS. Travel to Guam and several Caribbean islands was not funded under the AID PASA.

## Technical Assistance to Project Field Stations

### Bangladesh

Mr. Lynwood Fiedler, Wildlife Biologist, was in Bangladesh from September 21 to October 24, 1989, to assist the Government of Bangladesh and the USAID/DWRC-supported Vertebrate Pest Section and DWRC Project Leader Michael Jaeger in implementing a large-scale pilot demonstration of rodent control in rice. This rodent control demonstration was conducted in two 4,800-ha sites and tested the field efficacy and farmer acceptance of both control techniques and a rodent management strategy.

Dr. Robert Timm, Superintendent and Extension Wildlife Biologist, Hopland Field Station, University of California at Davis, completed a consultancy to Bangladesh for IPRS from November 18 to December 15, 1989, in support of the vertebrate pest project in Dhaka. Dr. Timm assisted Dr. Jaeger, Dr. Parvin Sultana (VPS counterpart), and Mr. Santosh Sarker (DAE) in creating and implementing a survey of Bangladesh farmers concerning their perceptions of, and need for, agricultural rodent control. Farmers were interviewed in two areas of Bangladesh before, during, and after implementation of a large-scale demonstration of rodent control in rice. Survey information will lead to recommendations as to whether trained farmers or trained government extension service personnel should undertake future rodent control efforts. This information is needed to determine where to place primary emphasis in future training efforts.

Table 7. International travel for technical assistance projects by USAID/DWRC personnel between October 1989 and September 1991.

| Date | Name | Location | Purpose of trip |
|---|---|---|---|
| **1989** | | | |
| Sep 11-Oct 13 | J. O. Keith | Senegal | Complete studies in Senegal of the impact on birds of insecticides used to control African migratory locusts and grasshoppers. |
| Sep 21-Oct 24 | L. A. Fiedler | Bangladesh | Assist the Vertebrate Pest Section in implementing a field research/demonstration project on preharvest rat control in rice. |
| Oct 8-Nov 12 | G. K. LaVoie | Chad and Guinea-Bissau | Chad: Provide initial field assistance in Chad to Dr. John Wilson in initiating a rodent population monitoring program near N'Gouri. Guinea-Bissau: Evaluate the pest status of rodents in agriculture and train a counterpart in rodent pest research and control techniques. |
| Oct 11-Nov 9 | J. Wilson[1] | Chad | Select and document two habitat areas typical of Sahelian agriculture systems, implement rodent monitoring, initiate bait acceptability trials, and train counterpart scientists in trapping, autopsy, and data collection methods. |
| Nov 18-Dec 15 | R. M. Timm[2] | Bangladesh | Assist Department of Agricultural Extension personnel in creating and implementing a tool to survey Bangladeshi farmers regarding current rodent control perceptions, efforts, and needs; make recommendations. |
| Nov 20-Dec 8 | R. L. Bruggers | Chad, Italy, and Morocco | Chad: Meet with USAID/MOA officials to implement the Rodent Control Research Project (RCRP). Rome, Italy: Discuss with Food and Agriculture Organization (FAO) officials DWRC's involvement in a bird pest research and management project in Argentina and Uruguay. Morocco: Discuss with USAID and MOA officials research and training of Moroccan scientists on evaluating the impact on the environment and nontarget wildlife of locust control sprays. |

[1] On sabbatical to DWRC from Queensland Institute of Technology in Australia.
[2] Superintendent and Wildlife Specialist, Hopland Field Station, University of California, Hopland, California.

Table 7. Continued.

| Date | Name | Location | Purpose of trip |
|---|---|---|---|
| Nov 27-Dec 16 | J. O. Keith | Morocco | Meet with officials regarding plans for scope of work, budget, procurement of supplies and equipment, hiring of a resident coordinator, and preparing for training sessions. |
| **1990** | | | |
| Jan 15-Feb 17 | F. F. Knowlton | Bangladesh | Review research efforts related to effects golden jackals have upon the Bangladesh agricultural production, and instruct Bangladeshi scientific officers in current predator research techniques and procedures. |
| Feb 4-24 | L. A. Fiedler | Argentina and Uruguay | Prepare 1-year plan of activities for implementing FAO Project "Integrated Control of Bird Pests." |
| Feb 13-Mar 10 | N. P. Groninger | Bangladesh and Pakistan | Bangladesh: Assist Project personnel in establishing data sets for research results and instruct them in other computer programming and software packages. Pakistan: Assist Project personnel in computer use and various statistical and data analysis software packages. |
| Feb 28-Mar 24<br>Mar 10-24 | R. L. Bruggers<br>M. W. Fall | Bangladesh and Pakistan<br>Pakistan | Bangladesh: Discuss funding support and TDY's. Pakistan: Develop a work plan for July 1990-June 1991, and identify critical issues that need to be resolved when the Project ends in July 1991. |
| Mar 14-Apr 3 | L. A. Fiedler | Italy, Malaysia, Indonesia, and the Philippines | Brief FAO officials on FAO consultancy to Argentina and Uruguay during February, present two papers and attend the 3rd International Conference on Plant Protection in the Tropics in Malaysia, determine the current rodent status in Indonesia, and discuss with International Rice Research Institute (IRRI) officials the details of an expert panel session on rodents in rice to be held in September 1991 in the Philippines. |
| Apr 1-25 | G. K. LaVoie | Chad | Suggest improvements in the N'Gouri rodent population monitoring study, consider other monitoring areas near Abeche, and facilitate the establishment of the new Rodent Control Research Project in Chad. |

Table 7. Continued.

| Date | Name | Location | Purpose of trip |
|---|---|---|---|
| May 7-26 | J. O. Keith | Morocco | Discuss the latest project plans and developments with officials in Morocco, select a field study area for training, and conduct training in Rabat. |
| May 21-Jun 2 | J. N. Gillis[3] | Morocco | Train Moroccan chemists in the methods of chemical analyses needed to monitor the impact on the environment and nontarget wildlife of locust control pesticides. |
| May 28-Jun 22 | G. K. LaVoie | Yemen | Survey rodents, provide methods to estimate their impact on agriculture, study methods of control, train Yemenis in rodent biology and control methods, and provide a list of equipment needed to furnish a rodent research laboratory. |
| Jun 17-Jul 2 | A. L. Kolz<br>R. L. Phillips | Morocco | Conduct a workshop on wildlife telemetry techniques for Moroccan scientists, and train the electronics staff at the Locust Control Center in Aït Melloul in operating their new radio location equipment. |
| Jun 25-Jul 3 | J. O. Keith | The Bahamas | Assess the Bahama parrot situation on Abaco Island in the Commonwealth of The Bahamas as to a serious loss of productivity in Bahama parrots due to predation by feral cats, and recommend steps to control feral cat populations. |
| Jul 22-Aug 18 | L. A. Fiedler | Belgium and Guinea-Bissau | Visit several rodent experts at the University of Antwerp in Belgium to discuss current rodent research in Africa, and participate in rodent field work in Guinea-Bissau. |
| Aug 7-Nov 20 | J. E. Brooks | Pakistan | Assist in implementing a new strategy for a large-scale rodent control demonstration in wheat and rice, assess rodent damage in rice, assist in the institutionalization of the Vertebrate Pest Control Laboratory, and implement radio tracking studies of wild boar. |

[3] Chemist, Environmental Protection Agency, Denver, Colorado.

Table 7. Continued.

| Date | Name | Location | Purpose of trip |
|---|---|---|---|
| Sep 7-18<br>Sep 7-20 | M. W. Fall<br>L. A. Fiedler | Philippines<br>Philippines and Hawaii | Participate in the "Expert Panel Meeting on Rice Rodent Control" hosted by IRRI in Los Baños, Philippines. Mr. Fiedler also visited the DWRC Field Station in Hilo, Hawaii, to participate in rodent damage control studies in sugarcane fields and macadamia nut orchards. |
| Sep 30-Oct 23<br><br><br>Oct 2-30 | J. O. Keith<br>M. L. Avery<br>G. K. LaVoie<br>P. C. Matteson[4] | Morocco | Provide training in field methods for determining the biology and relative numbers of birds, mammals, and beneficial insects in study areas. |
| Oct 2-Nov 2 | R. E. Johnson | Pakistan | Assist in trapping, instrumenting, and radiotracking wild boar, and provide training in radiotelemetry techniques. |
| Oct 7-31 | P. J. Savarie | Chad | Assist the Chad RCRP with rodent research and develop an outline on the toxicity and safety aspects of zinc phosphide and warfarin for use in a rodent control workshop to be conducted for personnel in the Chad MOA. |
| Nov 29-Dec 5 | R. L. Bruggers | Chad and Italy | Dr. Bruggers' airplane was diverted from Chad before landing due to a coup. In Rome, he met with FAO officials. |
| Dec 1-14 | J. O. Keith | Morocco | Select a study area for conducting the proposed experiment with malathion and dichlorvos, and discuss final plans for the study with Moroccan government officials. |
| Dec 7-18 | R. M. Engeman | Morocco | Provide training in experimental design as well as statistical concepts and methods to Moroccan scientists and administrators that will be involved in the field research phase of the project. |
| **1991** | | | |
| Apr 1-May 1 | M. M. Jaeger | Argentina and Uruguay | Evaluate the major bird pest problems and recommend a strategy of lethal control for each of the major problem areas. |

[4] Entomologist from Iowa State University, Ames, Iowa.

Table 7. Continued.

| Date | Name | Location | Purpose of trip |
|---|---|---|---|
| Apr 5-May 1 | J. E. Brooks | Chad | Assist Chad RCRP in population monitoring studies, damage assessments methods to vegetable and grain crops, and food and bait preference studies. |
| Apr 10-May 3 | R. W. Bullard | Argentina and Uruguay | Review bird problems relative to cropping patterns, chemical control practices, and assist bird control specialists in designing experiments, defining bird problems, and developing a control strategy. |
| May 15-Jun 29 | J. E. Brooks | Pakistan | Close out DWRC full-time involvement in the VPCP, arrange for equipment transfer, and investigate mechanisms for continued short-term coordination and cooperation among DWRC, VPCL/NARC/Islamabad, and the principal investigators at the University of Agriculture, Faisalabad. |
| May 29-Jun 7 | P. J. Savarie | Hawaii and Guam | Attend XVII Pacific Science Congress meeting held in Hawaii on May 30-31, 1991, which included a symposium on "Impact of the brown tree snake on the fauna of Guam," and visit Guam to assess situation of brown tree snake for future fumigant trials. |
| Jun 17-Jul 18 | J. O. Keith | Argentina and Uruguay | Visit areas treated for bird control to assess the environmental conditions, suggest alternatives, and present a short training course in methods for studying ecotoxicology. |
| Jul 13-18 | R. D. Curnow | Guam | Represent DWRC at discussions with Government of Guam and U.S. representatives regarding DWRC research capabilities for developing methods to control the brown tree snake. |
| Aug 10-Sep 4 | G. K. LaVoie | Chad | Assist in monitoring Sahelian rodent densities, initiate bait toxicology trials, conduct bait preference trials, develop vegetable damage assessment methods, and initiate a study to determine rodent feed patterns from analysis of stomach contents. |

Table 7. Continued.

| Date | Name | Location | Purpose of trip |
|---|---|---|---|
| Aug 13-Sep 6 | J. O. Keith | Grand Cayman, Puerto Rico, St. Lucia, and Barbados | Provide technical assistance to several Caribbean countries on various wildlife situations: endangered parrots damaging fruits and other crops on Grand Cayman; the pearly-eyed thrasher causing crop damage and preying on nests of the endangered Montserrat oriole in Puerto Rico; mongooses, previously introduced to control rats in sugarcane, possibly causing the demise of endangered lizards and ground-nesting birds on St. Lucia; and mongooses carrying rabies on Grenada. Consult with Barbados officials regarding technical assistance and conservation issues. |
| Sep 15-Oct 9<br>Sep 17-Oct 3<br>Sep 25-Oct 4<br>Sep 23-27<br>Sep 27-30 | P. J. Savarie<br>W. Scott Wood[5,6]<br>R. L. Bruggers<br>G. C. Mitchell[6]<br>R. M. Engeman[6,7] | Guam | Conduct tests in a simulated nonfood cargo situation on Guam to determine the effectiveness of methyl bromide as a fumigant for control of brown tree snakes. |
| Sep 20-Oct 11 | R. W. Bullard | Argentina and Uruguay | Complete second segment of consultancy regarding nonlethal chemical control of bird pests and assist bird control specialists in their study design. Present six lectures and participate in a training course "Curso Binacional Sobre Manejo Integrado de Aves Plaga" at Salto, Uruguay. |

[5] Biological Scientist, Technology Support Staff, USDA/APHIS, Hyattsville, Maryland.
[6] Travel was coordinated through IPRS.
[7] Dr. Engeman traveled to Guam while on sabbatical in Brisbane, Australia.

Dr. Fred Knowlton, Wildlife Biologist from DWRC's Field Station in Logan, Utah, consulted for IPRS in Bangladesh between January 15 and February 17, 1990, assisting the VPS in a jackal research project. Specifically, Dr. Knowlton helped Project counterpart scientists capture and radio-instrument jackals and jungle cats, explored the use of scat counts and vocalizations as techniques for estimating jackal abundance, and provided guidance in developing a long-term jackal research program.

Ms. Paige Groninger, Computer Programmer Analyst, traveled to Bangladesh from February 13 to March 5, 1990, to assist and train VPS personnel in computer use, including SAS, a statistical package used for analyzing research data.

Dr. Richard Bruggers visited Bangladesh from February 28 to March 9, 1990, and met with Dr. Michael Jaeger, VPCL scientists and staff, and USAID personnel to discuss vertebrate pest management research and related activities.

### Chad

Dr. John Wilson, Research Director, Centre for Biological Population Management, Queensland University of Technology, Brisbane, Australia (on sabbatical at DWRC), consulted for the DWRC/IPRS in Chad, Africa, between October 11 and November 9, 1989, to assist the AID/N'Djamena and MOA in initiating a rodent monitoring study. During this visit, monitoring sites were established in two subregions (N'Gouri and Abeche). The monitoring sites encompass the range of habitats available to rodents in the subregions. Bait trials were undertaken in various habitats to determine a suitable bait for use during the remainder of the study. The counterpart and cooperators were trained in trapping, autopsy and data coding techniques, and the initial monitoring of rodent population density and structure was implemented in the N'Gouri subregion. The counterpart and the cooperators from the MOA continued monitoring these sites on a monthly basis to provide the database necessary to understand population demographics, which should prove valuable toward forecasting rodent outbreaks.

Mr. Keith LaVoie, Wildlife Biologist, visited Chad between October 8 and 19, 1989, to work with AID/N'Djamena on plans for laboratory facilities and housing for the planned USAID/DWRC project. Mr. LaVoie also accompanied Dr. John Wilson to the N'Gouri area where they initiated a long-term rodent monitoring project.

Dr. Richard Bruggers traveled to Chad between November 20 and 29, 1989, to work with USAID and MOA personnel in implementing the USAID/DWRC Rodent Control Research Project (RCRP) Field Station.

Mr. LaVoie returned to Chad between April 1 and 25, 1990, to continue field work and training to determine rodent species composition and monitor rodent densities in Sahelian agricultural areas. In addition to updating field sampling methods, Mr. LaVoie evaluated progress and made final preparations for the new Field Station.

In June 1990, Dr. Juan Spillett, Wildlife Biologist, joined DWRC as Project Leader for the new rodent research station in Chad, Africa. Dr. Spillett participated in briefing sessions in Denver and Washington, D.C., before assuming his duties in N'Djamena on July 3, 1990.

Dr. Peter Savarie, Research Pharmacologist, traveled to Chad during October 7 and 31 to assist the RCRP with rodent research and training activities. He cooperated with Dr. Spillett and Dr. Mornan Kounade, Project Assistant, in developing a rodenticide toxicity lecture for a rodent control research workshop that was held for Chad MOA/CPS technicians in November 1990. Dr. Savarie trained Project personnel in procedures and techniques for laboratory and field testing of rodenticides.

On December 1, 1990, while *en route* to Chad to consult with Dr. Spillett regarding rodent control research activities, Dr. Richard Bruggers' plane was diverted to the Central African Republic because of internal strife within Chad. Meanwhile, Dr. Spillett and his family were evacuated. During his time in the United States, Dr. Spillett analyzed data and drafted material on population characteristics of rodents in Chad. Dr. Spillett resumed his duties in Chad on March 15, 1991.

Mr. Joe Brooks, Wildlife Biologist, visited Chad from April 5 to May 1, 1991, to assist Dr. Spillett and the RCRP in developing methods to assess rodent damage to vegetable crops, initiate baiting trials to determine which baits best deliver toxicants to rodent pests, and develop simpler methods for implementing a long-term rodent population monitoring program.

Mr. Keith LaVoie, now retired, consulted for DWRC between August 10 and September 4, 1991, at the DWRC Field Station in Chad. Mr. LaVoie assisted Dr. Spillett in monitoring rodent populations at two agricultural sites and in initiating a study comparing rodent control methods.

## Morocco

Dr. Richard Bruggers traveled to Morocco between December 2 and 8, 1989, to work with USAID and MOA personnel regarding implementing a new PASA for research and training of Moroccan scientists on evaluating the impact of locust control sprays on the environment and nontarget wildlife.

From November 27 to December 16, 1989, Dr. James Keith, Wildlife Biologist, worked in Rabat, Morocco, with the USAID Mission and the Moroccan Plant Protection Department in planning for a cooperative project. The objectives of this project were to train Moroccan scientists in methods used in ecotoxicological research and then to conduct an experimental evaluation of the effects of locust insecticides on nontarget animals. Dr. Keith helped the group resolve details concerning training sessions, proposed research, budgets, project documents, and the procurement of equipment and supplies.

Mr. John McConnell began working for the IPRS in April 1990. After spending 2-3 weeks in Denver, Mr. McConnell traveled to Morocco during May to serve as DWRC's Logistics Coordinator for this research and training project.

During 1990 the DWRC conducted a series of training courses in Morocco on procedures for evaluating the environmental effects of pesticides:

Dr. James Keith returned to Morocco between May 7 and 26, 1990, to select field areas for training and to provide an introductory training session in Rabat.

Dr. John Gillis, EPA Chemist, traveled to Morocco between May 21 and June 2, 1990, to train Moroccan chemists in chemical methods for conducting this research to evaluate the effects of locust control insecticides on the environment.

Messrs. Larry Kolz, Electronics Engineer, and Robert Phillips, Wildlife Biologist, traveled to Morocco between June 17 and July 2, 1990, to provide both laboratory and field training to 15 individuals in general methods of radiotelemetry for ecotoxicological studies and specific techniques used to capture and attach radio transmitters to birds and mammals. They also followed radio-equipped animals to determine their responses to pesticide applications.

Between September 30 and October 23, 1990, Dr. James Keith, Mr. Keith LaVoie, and Dr. Michael Avery, Wildlife Biologist from DWRC's Gainesville, Florida, Field Station, provided training in field methods for determining the relative number of birds, mammals, and beneficial insects in study areas. The session, which was conducted out of a field camp, included 14 Moroccan biologists and Dr. Patricia Matteson, Entomologist from the Corsortium for International Crop Protection. Techniques for counting and capturing vertebrates and invertebrates were demonstrated as well as dissection to prepare study skins, examine food habits, and remove brains for cholinesterase analysis.

During December 1990, Drs. Keith and Richard Engeman, Statistician, traveled to Morocco to train Government of Morocco personnel in statistical procedures for evaluating the environmental effects of pesticides. Dr. Keith selected plots and made preparations for the experimental phase of training, and Dr. Engeman conducted training in procedures for sampling and data analysis as related to environmental monitoring.

This program, supported by the USAID/Rabat, culminated in a 5-week field study in early 1992 to assess the nontarget impacts from experimental applications of dichlorvos (DDVP) and malathion, which have been widely used in Morocco for locust control. The study had been originally scheduled for 1991, but it was delayed due to the Persian Gulf War.

## Pakistan

Ms. Paige Groninger, Computer Programmer Analyst, traveled for IPRS to Pakistan from March 6 to 10, 1990, to assist and train Vertebrate Pest Control Project (VPCP) personnel in the use of SAS statistical and data analysis packages for storing, analyzing, and graphing research results.

Drs. Richard Bruggers and Michael Fall, Chief, Predator Control Research Section, visited Pakistan from March 10 to 24, 1990, to meet with DWRC Project Leader, VPCP scientists and staff, and USAID personnel to discuss vertebrate pest management research and related activities. They assisted in evaluating past activities of the VPCP and initiating detailed work plans, objectives, and guidelines for the follow-on project.

Mr. Brooks traveled to Pakistan between August 7 and November 20, 1990, to assist the VPCP in conducting rodent field trials and continuing wild boar studies. This was the first of several TDY's whereby DWRC provided technical assistance and backstopping support to the Project until June 1991. During this 3½-month TDY, Mr. Brooks cooperated with Mr. Ejaz Ahmad, AID/VPCP Team Leader; Mr. A. Aziz Khan, Principal Scientific Officer; and other Pakistani counterparts in working with selected farmers to implement a new strategy of rodent control technology transfer in wheat and rice. Preharvest data from damage assessments in rice indicated that the selected cooperating farmers had 90% less rodent damage than other farmers in the same villages. In addition, wild boar were trapped, fitted with radio transmitters, and tracked in both irrigated and rainfed agricultural areas. Four animals were fitted with radio collars, and one penned, male wild boar was successfully surgically implanted with a radio transmitter in his abdomen. The study was initiated to determine the movement patterns and potential damage by boar to agriculture.

Mr. Richard Johnson, Electronics Technician, visited Pakistan from October 2 to November 2, 1990, to train and/or assist Mr. Brooks and NARC scientists in (1) trapping wild boar, (2) operating electronic equipment, (3) fastening radiotelemetry collars to the animals and tracking them in the field, and (4) keeping the necessary records before and after releasing an instrumented animal. Mr. Johnson also assisted in surgically implanting a radio transmitter in the wild boar mentioned above.

Mr. Brooks again visited Pakistan between May 15 and June 29, 1991, to close out DWRC full-time involvement in the VPCP; arrange for transfer of equipment, supplies, and vehicle to the VPCL/NARC; investigate mechanisms for continued short-term coordination and cooperation among the DWRC, VPCL/NARC at Islamabad, and the principal investigators at the University of Agriculture, Faisalabad; and complete the technical and final VPCP reports.

## Technical Assistance to Other Countries

Mr. Lynwood Fiedler traveled to Italy, Malaysia, Indonesia, and the Philippines from March 14 to April 3, 1990. Mr. Fiedler presented two papers at the 3rd International

Conference on Plant Protection in the Tropics in Malaysia and met with Malaysian rodent biologists to discuss rodent research and control that has application throughout southeast Asia. In Indonesia, he discussed rodent pest management with USAID and Indonesian scientists. Also, Mr. Fiedler assisted the International Rice Research Institute (IRRI) in the Philippines, at their request, in planning a rodent control conference which was held at IRRI in 1990.

Between July 22 and 28, 1990, Mr. Fiedler traveled to Belgium to meet with several rodent experts at the University of Antwerp to discuss current rodent research in Africa and results from a recently completed, Danish-supported rodent project in Tanzania.

### Rodent Surveys in Guinea-Bissau

Mr. Keith LaVoie visited Guinea-Bissau between October 20 and November 12, 1989, to assess rodent pests in agriculture and train a counterpart in rodent pest control techniques. Mr. LaVoie's consultancy involved trapping rodents in three agricultural areas to determine species composition and relative rodent densities (Table 8). He snap-trapped rodents for several days near Bula (Agricultural Zone 1, east central) and Catio and Caboxanque (Agricultural Zone 3, coastal) using dried fish for bait. In harvested vegetable fields near Bula, 96 trap nights resulted in the capture of 8 specimens, 1 *Mastomys erythroleucus*, 5 *Mastomys natalensis*[1] and 2 *Mus* sp.; this was an 8.3% trap success (unadjusted for sprung or lost traps). In Catio and Caboxanque, the same two *Mastomys* species were captured in swamp rice, upland rice, and vegetable fields; but no *Mus* sp. was trapped. Trap success in this second area was 27% (unadjusted). The black rat (*Rattus rattus*) was captured (4 in 12 trap nights) in grain storage buildings in Bula and Catio. Two other rodents, an African ground squirrel (*Euxerus erythropus*), seen on many occasions along the road from Catio to Caboxanque in Zone 3 (about 5-11 animals per kilometer), and the giant pouched rat (*Cricetomys gambianus*), were reported to damage rice and vegetable crops on the Island of Bubaque. Rodents apparently are popularly used as a human food source in Guinea-Bissau. Harvesting them for food may reduce crop damage, but the degree to which this occurs needs to be verified.

Mr. Lynwood Fiedler also traveled to Guinea-Bissau between July 29 and August 18, 1990, to work with AID/Bissau and counterparts within the MOA/CPS to continue to evaluate rodent damage problems in priority crops. Several agricultural crops growing near the towns of Bula, Bissau, Bafata, and Contuboel were examined for damage, and rodents were trapped to determine species present and current infestation levels. Results are summarized in Table 9. Study skins also were made from all collection sites and left with CPS Department personnel for their use as a reference collection while they continue to investigate these rodent problems.

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[1] *Mastomys* spp. were identified by D. Wilson, U.S. Museum of Natural History, Washington, D.C.

Table 8. Guinea-Bissau rodent surveys conducted during October and November 1989.

| Zone | Location | Crop | Captures *Mastomys erythroleucus* | Captures *Mastomys natalensis* | Captures *Mus* sp. | Trap nights | % success |
|---|---|---|---|---|---|---|---|
| 1 | Bula | Vegetables | 1 | 2 | | 48 | 6 |
| | | Vegetables | | 3 | 2 | 48 | 11 |
| 3 | Catio | Swamp rice | | 6 | | 24 | 25 |
| | | Upland rice | 3 | 3 | | 6 | 100 |
| 3 | Caboxanque | Swamp rice | | 9 | | 19 | 47 |
| | | Vegetables | 4 | 6 | | 48 | 21 |
| | | Swamp rice | 2 | 3 | | 20 | 25 |
| | | Vegetables | 3 | — | - | 25 | 12 |
| | Totals | | 13 | 32 | 2 | 238 | 20 |

Note: In Bula and Catio, 12 trap nights in two grain storage buildings resulted in the capture of 4 *Rattus rattus*.

In Argentina and Uruguay, parakeets build large communal nests in palm trees.

Table 9. Results from snap-trapping in four areas of Guinea-Bissau during August 1990.

| Date | Location | No. traps | Traps | | | Catches | | % Trap Success* | | Weather |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sprung | Unsprung | Missing | Rodent | Other | Adj | Unadj | |
| 1990 | | | | | | | | | | |
| Aug 2 | Ponate | 50 | 14 | 35 | 0 | 1 | 0 | 2.4 | 2.0 | Rain |
| Aug 3 | Ponate | 50 | 7 | 40 | 1 | 2 | 0 | 4.7 | 4.0 | No rain |
| | Total | 100 | 21 | 75 | 1 | 3 | 0 | 3.6 | 3.0 | |
| Aug 8 | Granja Pessube | 52 | 0 | 44 | 8 | 0 | 0 | 0.0 | 0.0 | Rain |
| Aug 9 | Granja Pessube | 51 | 4 | 31 | 16 | 0 | 0 | 0.0 | 0.0 | No rain |
| | Total | 103 | 4 | 75 | 24 | 0 | 0 | 0.0 | 0.0 | |
| Aug 14 | Contuboel | 50 | 1 | 46 | 1 | 1 | 1 | 4.3 | 4.5 | Rain |
| Aug 15 | Contuboel | 42 | 1 | 27 | 22 | 0 | 0 | 0.0 | 0.0 | Rain |
| | Total | 92 | 2 | 73 | 23 | 1 | 1 | 1.3 | 1.3 | |
| Aug 14 | Bafata | 48 | 2 | 46 | 0 | 0 | 0 | 0.0 | 0.0 | Rain |
| Aug 15 | Bafata | 49 | 4 | 38 | 3 | 3 | 1 | 7.0 | 6.4 | Rain |
| | Total | 97 | 6 | 84 | 3 | 3 | 1 | 3.3 | 3.2 | |

$$\text{* Adjusted} = \frac{\text{No. catches}}{\text{No. catches + unsprung traps + 0.5 (sprung traps)}} \times 100 = \%$$

$$\text{Unadjusted} = \frac{\text{No. catches}}{\text{No. catches + sprung and unsprung traps}} \times 100 = \%$$

### Control of Bird Pests in Argentina and Uruguay

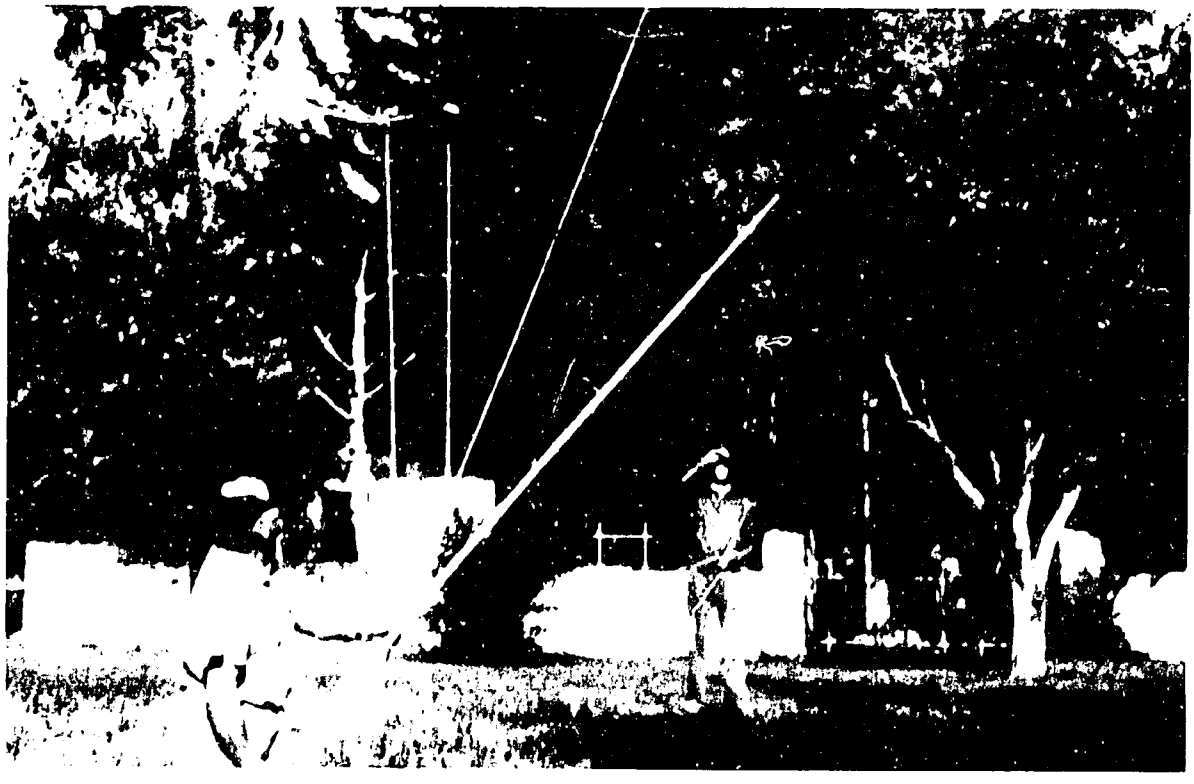
Dr. Richard Bruggers was in Rome, Italy, from November 29 to December 1, 1989, and November 29 to December 5, 1990, to meet with FAO officials and discuss DWRC's involvement in an FAO-supervised bird pest research project "Integrated Control of Bird Pests." DWRC conducted bird pest consultancies for FAO to these countries during 1990 and 1991.

Mr. Lynwood Fiedler consulted in Uruguay and Argentina between February 4 and 24, 1990, to work with MOA officials from these two countries to help develop a project document. Mr. Fiedler gathered information regarding the bird pests of Uruguay and Argentina; developed a listing of future personnel, expenses, and activities for the project; assisted in organizing a training program for each country's bird control units; and prepared a report outlining needed followup activities.

Dr. Michael Jaeger, Wildlife Zoologist, was in Argentina and Uruguay between April 1 and May 1, 1991. Dr. Jaeger reviewed current lethal control practices for damage by doves and pigeons to ripening cereals and sprouting sunflowers and damage by parakeets to ripening sunflowers, fruits, and cereals and recommended alternative or

improved techniques where applicable. Chemical toxicants have been the principal method used to control both problems. Farmers use poisoned grain baits to kill doves and pigeons, and government-organized control teams apply toxic grease to the nest entrances of parakeets. Governments in both countries are now seeking safer, less persistent chemicals. Dr. Jaeger recommended that CPT (3-chloro-*p*-toluidine) and its acid salt CPTH be evaluated in a systematic program of research to develop a selective strategy for bird pest control in these countries.

Mr. Roger Bullard, Research Chemist, consulted in Argentina and Uruguay from April 10 to May 3, 1991, to review general bird problems and cropping patterns in the main geographical area of concern, assist in defining and developing a strategy for bird problems with respect to agronomic control methods, and aid bird control specialists in designing specific experiments. Mr. Bullard traveled again to Argentina and Uruguay between September 20 and October 11, 1991, to present six lectures to approximately 30 individuals at a 5-day, binational training course on integrated control of bird problems in agricultural crops in these two countries. The topics for Mr. Bullard's lectures centered on bird repellents, nonlethal methods of damage control, and ecotoxicological concepts and applications. Mr. Bullard also assisted counterpart scientists in each country with preparing research studies, designing testing facilities, and observing pigeon damage problems in emergent sunflowers.



Current control techniques include putting a toxic grease in the nest entrances. Birds contact the poison when entering or leaving, and they injest the toxicant while grooming the grease from their feathers.

Dr. James Keith was in Argentina and Uruguay between June 17 and July 18, 1991, to provide technical assistance concerning potential ecotoxicological problems associated with controlling bird pests. Dr. Keith visited areas treated for bird control to assess the environmental conditions, analyzed environmental risks of current control practices, suggested alternate bird damage control methods, and prepared protocols for environmental studies on residue analysis, cholinesterase, contamination and exposure and effects of pesticides on target and nontarget animals as a result of bird control practices.

### Brown Tree Snake Research in Guam

Between May 29 and June 7, 1991, Dr. Peter Savarie attended the XVII Pacific Science Congress meeting in Honolulu, Hawaii, which included a 2-day symposium about brown tree snakes. Dr. Savarie then traveled to Guam to begin discussions with appropriate individuals on designing a research plan to develop methods to prevent the brown tree snake from dispersing from Guam to other Pacific Islands.

In June and July 1991, USDA/APHIS/DWRC entered into an Interagency Agreement with the U.S. Fish and Wildlife Service/National Ecology Research Center. The IPRS is coordinating DWRC's research effort. The first study was to evaluate methyl bromide as a fumigation test in cargo containers. Dr. Savarie was assisted by Mr. W. Scott Wood, a USDA-certified methyl bromide fumigator from S&T in Hyattsville, Maryland. Other cooperators included personnel from the U.S. Navy, Guam Department of Agriculture, Guam Environmental Protection Agency, U.S. Fish and Wildlife Service, USDA/ADC, two private shipping companies on Guam, a private pest control company (No Ka Oi), and USDA/Plant Protection and Quarantine on Guam. Fumigation of cargo that has a high risk of harboring snakes is one potential method for preventing their dispersal.

A simulated nonfood cargo situation was then established during September and October 1991. Eighteen snakes were randomly positioned in a 1,685-$ft^3$ cargo container for each fumigation test. Methyl bromide was applied at rates of 1.5 lbs/2 hrs, 1.5 lbs/1 hr, 0.75 lbs/2 hrs, and 0.75 lbs/1 hr, all per 1,000 $ft^3$. All snakes died within about 18 hrs at the 1.5 lbs/2 hrs rate and within 2+ days at 0.75/2 hrs. Thirty-two of 36 snakes were dead after 3 days at the 1.5 lbs/1 hr rate, but all were dead by 11 days. Only 1 snake was dead after 10 days at the 0.75 lbs/1 hr rate. Methyl bromide is registered with the Environmental Protection Agency for many fumigation purposes and is regularly used on Guam. Modification of certain registration labels will hopefully make it available as a tool to help reduce snake dispersal to other Pacific islands.

### Studies on Effect from Locust Insecticides in Senegal

An international group of scientists met at FAO headquarters in Rome in February 1989 to plan a pilot study of the ecological effects of experimental fenitrothion and chlorpyrifos treatments to small research plots. As a result, between June and October

1989, Dr. James Keith participated in a research project sponsored by FAO and USAID to investigate the impact on the environment and nontarget wildlife of large-scale grasshopper control in Senegal, West Africa. One aspect of this investigation looked into the impact of chlorpyrifos and fenitrothion (two insecticide sprays) on the food items eaten by breeding birds--in this case, the ground nesting singing bush-lark (*Mirafra javanica*). These larks predominantly feed on insects; about 90% of the food items in their gizzards were insect remains--mostly grasshopper instars. No direct mortality of adults was found in sprayed areas. Debilitated young had depressed cholinesterase levels, and many young birds died on treated plots. Contaminated insect foods may have poisoned these young. Likewise, after treatments, 17 of 38 (45%) larks examined from sprayed plots had eaten seeds, suggesting that, as insect biomass decreased, the larks may have been forced to feed on seeds. Treatments also may have decreased lark nesting success, probably due to the adults abandoning their nests and moving to areas with greater insect abundance.

### Rodent Damage in Yemen

Between May 28 and June 22, 1990, Mr. Keith LaVoie conducted a survey of rodents to assess their economic impact on postharvest food in the Republic of Yemen. The areas surveyed were the central highlands near Sana'a and Dhamar at about 2,300 m above sea level, the southern highlands near Ibb and Taiz at 2,800 m and 2,500 m above sea level, respectively, and the Red Sea Tihamah coastal region. Heavy infestations of black rats were found in all storage structures, markets, and other buildings in all areas surveyed. Other rodents found in buildings were house mice (*Mus musculus*) in the highlands and Norway rats (*Rattus norvegicus*) in storage areas in coastal regions. Several farmers and Agricultural Research Authority (ARA) personnel reported damage to field cereal grains. Heavy infestations of the sand rat (*Meriones rex*) were subsequently found adjacent to fields in the central and southern highlands. These large jirds can consume and store large quantities of cultivated and noncultivated seeds. Black-tufted gerbils (*Gerbillus famulus*) also were trapped in the central highlands and, although they appear to have a wide distribution, their pest status has not been described. In addition to this survey work, a 2-day class in general rodent biology, identification, and damage assessment methods was presented to ARA personnel.

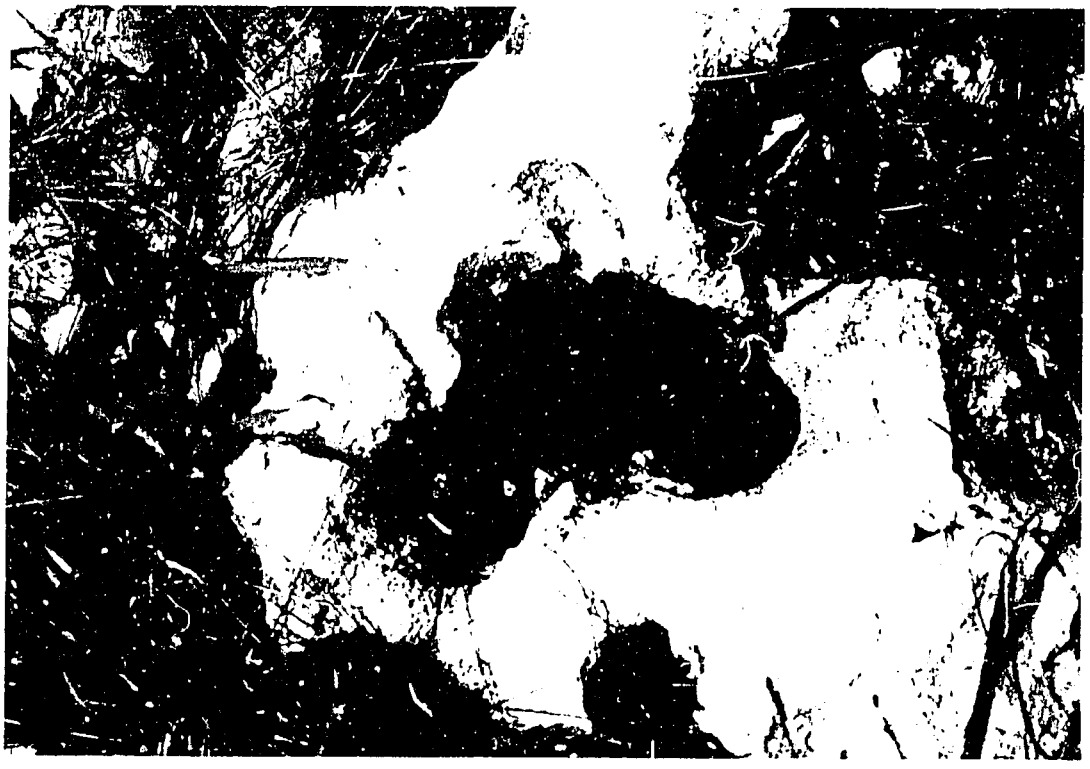
### Vertebrate Pests in the Caribbean--Endangered Species

Dr. James Keith spent June 25 to July 3, 1990, on Abaco Island in The Bahamas to determine means of reducing predation by feral house cats on the Bahama parrot. The parrot has been listed as endangered by the International Union for the Conservation of Nature since 1966 and by USDI since 1970. Habitat loss is the primary cause of decreasing populations, but cat predation also is a factor. Biologists found that cats caused the failure of 45% of nests under study in 1988. In 50% of the cases, female parrots were killed. In 1989 only fenced nests survived in the main study area. The Bahama parrot on Abaco is especially susceptible to predation as it nests in underground cavities in the limestone substrate.

In early 1991, IPRS received a number of other inquiries from Caribbean countries about a variety of concerns over birds and mammals. Several of these problems were evaluated during a trip in August by Dr. James Keith. Endangered parrots (*Amazona* spp.) that live on several islands in the Caribbean need protection, as their populations have decreased with the loss of habitat to agriculture. On islands such as Grand Cayman, farmers are antagonized by the parrots because these birds damage fruits and other crops. To protect the parrots, methods are needed to protect the crops from damage. On Montserrat, one of the avian predators attacking parrots nests, the pearly-eyed thrasher (*Margarops fuscatus*), also preys on nests of the endangered Montserrat oriole (*Icterus oberi*); in addition, it also causes crop damage. Mongooses were introduced on islands such as Saint Lucia to control rats in sugarcane. Biologists feel these carnivores are responsible for the demise of endangered lizards and ground-nesting birds. On Grenada, mongooses are the principal carrier of rabies, although mongoose control has been practiced there for decades. These problems and relationships need to be resolved. A technique developed by DWRC in Hawaii using diphacinone for mongoose control should be tested in Grenada.

Mature pine forests are the preferred habitat for Bahama parrots, as pine seed is a principal food. Fire and logging have degraded much of the parrot habitat in The Bahamas.

Logging roads provide access to Bahama parrot nesting areas where humans discard unwanted house cats that later become parrot predators.



The Bahama parrot nests underground in solution cavities formed by water percolating through the limestone bedrock. Nests can readily be located by introduced mammalian predators, which attack adults and eat their eggs and young parrots.

## Supportive Research Activities

Mr. Shahid Munir, Scientific Officer from the VPCL/NARC in Islamabad, Pakistan, visited the DWRC from November 25, 1989, to January 5, 1990, to learn techniques to measure the stability of rodenticides under different environmental conditions and evaluate their effects on nontarget animals.

Both Ms. Maria Elena Zaccagnini and Ms. Ethel Rodriguez, graduate students at Colorado State University from Argentina and Uruguay, respectively, have successfully passed their written and oral comprehensive exams for entrance into Ph.D. programs in wildlife management. Ms. Zaccagnini began her field research in Argentina in December 1989 on the "Spatial-temporal response of foraging pigeons to an agricultural landscape in Argentina." Ms. Rodriguez began her Ph.D. research in Uruguay during December 1989 on the subject of "Strategy development in the use of secondary repellency for reducing eared dove damage on sorghum crops." Both researchers have worked closely with DWRC scientists for their M.Sc. degrees and will continue this association through IPRS for their doctorate degrees.

The DWRC/IPRS coordinated a 1-month research/study tour of the DWRC Bird Control Research Section (BCRS) Field Stations for Dr. Hassan Ibrahim El Deeb. Dr. El Deeb is Director, Harmful Animal Research Department in the Egyptian Ministry of Agriculture. Dr. El Deeb obtained support from USAID for this tour. In May, he visited with BCRS scientists at the DWRC and Field Stations in Fargo, North Dakota, and Gainesville, Florida, where he participated in breeding bird surveys and repellent and behavioral studies.

Dr. Hassan Farrag, rodent researcher for the Agricultural Research Corporation in Sudan, visited DWRC between August 5 and 7, 1991, with support from the World Bank. Dr. Farrag has been actively involved in maintaining rodent control practices in the Gezira, a 1,000,000-ha agricultural scheme that grows cotton, groundnuts, sorghum, wheat, and a variety of vegetables. DWRC has worked intermittently with Dr. Farrag and other Sudanese scientists since the mid-70's on a variety of rodent projects in the Sudan. Dr. Farrag also spent 10 days working in Ohio at the DWRC Sandusky Field Station and Bowling Green State University.

## Quelea Book and Other Publications

Oxford University Press published the book, "*Quelea quelea*: Africa's Bird Pest." Dr. Richard Bruggers is senior editor for this book, which brings together the results of much of the work that has been carried out during the past 20 years by many different investigators and research teams. The 25 chapters are authored by 26 individuals (including 8 DWRC scientists), representing 9 nationalities. Topics covered include all aspects of quelea ecology and management, its distribution, population, migration patterns and breeding behavior, monitoring and marking, and methods of control.

Mr. Lynwood Fiedler continued work on a technical paper, "Rodent Pest Management in Eastern Africa," for the Food and Agriculture Organization of the United Nations. The paper summarizes rodent pest problems in agriculture and health in eastern Africa, describes current methods of control, and suggests some management techniques for use against 12 major rodent pests within the region.

Mr. Fiedler and Dr. Michael Fall, Chief, Predator Control Research Section, are coauthoring a chapter entitled "Rodent Control in Practice: Tropical Open-field Agriculture" for 1992 publication in a book "Rodent Pests and Their Control," published by the Commonwealth Agricultural Bureaux International, United Kingdom.

In 1987, Dr. Sohail Soliman, Department of Zoology, Faculty of Science, Ain Shams University, Abbasia, Cairo, Egypt, was accepted on a postdoctorate position at Colorado State University. He conducted his research at the DWRC between November 1987 and May 1988. During 1989 Dr. Soliman published the results of this research in an article entitled "The use of a zinc phosphide/molasses gel and a brodifacoum/molasses gel delivery system for the control of *Rattus norvegicus* and *Mus musculus*" in the Bulletin of the Zoological Society of Egypt. Dr. Soliman explored the concept of contaminating fur of rodents with a suitable substance containing a rodenticide. Since most rodents groom foreign substances contaminating their fur, they would then ingest the poison during grooming. His results indicated that the technique was successful with wild mice, but not with wild rats.

## Participation in Meetings, Conferences, and Seminars

Dr. James Keith was invited by the University of California, Davis, to present an ecotoxicology seminar on May 1, 1990. Dr. Keith's presentation was "Specificity in pesticide use as a means of environmental protection: an example from predator control." This seminar is part of a seminar series sponsored by the Ecotoxicology Training Program at the University of California.

Between September 10 and 14, 1990, the International Rice Research Institute (IRRI) in Los Baños, Philippines, hosted an Expert Panel Meeting on Rice Rodent Control. The panel included 14 experts from Australia, England, India, Japan, Malaysia, Philippines, Switzerland, the United States, and Germany. Dr. Michael Fall and Mr. Lynwood Fiedler represented the DWRC. The purpose of this meeting was to assemble expertise from around the world to propose fresh solutions to the problem of crop losses due to rodents, especially in rice agriculture. Since its founding in 1962, IRRI has had to annually expend considerable money and labor in protecting valuable experimental plots and unique rice varieties from constant rodent invasion. The expert panel of scientists examined prospects for solutions to rodent damage and losses on agricultural experiment stations as well as in farmers' fields and within rural communities. Presentations and discussions summarized research efforts, described programs, identified problems with extension of rodent control technology, and outlined some new work, such as biological control, that may lead to more effective ways to reduce rice losses and the impact of rodents on community well-being. It became

apparent that effective control measures are available for principal pest species and that a major issue is the need to increase emphasis on effective organization and management of operational control problems. The need for innovative extension efforts to help farmers realize the benefits of improved rodent control was stressed. Recommendations ranged from improving coordination and communication among scientists addressing these problems, to long-range educational programs, and increasing public awareness of rodent damage and associated health problems. Panel members were also concerned that external assistance programs be evaluated on their sustained impact at intervals after funding completion so that future management efforts can be planned effectively. Finally, the panel agreed that future research and management programs should be aimed at more effective, selective rodenticide use by developing programs that apply the principles of integrated pest management.

Mr. Joe Brooks and other DWRC scientists attended the "World Health Organization/ APHIS Consultation on Baits and Baiting Delivery Systems for Oral Immunization of Wildlife against Rabies" meeting at Colorado State University, Fort Collins, Colorado, July 10-12, 1990.

Dr. Michael Jaeger attended the "Wildlife 2001: Populations" Conference in Oakland, California, July 29-31, 1991. This international conference brought together specialists from around the world to address state of the art research and management at the population level and was a followup of the highly successful Wildlife 2000: Habitat Modeling conference. Dr. Jaeger presented a paper "Selected control of Quelea populations in Africa" in the session on Overabundant Populations.

**Training**

IPRS continued collaboration with the Department of Fishery and Wildlife Biology at Colorado State University (CSU), Fort Collins, in international vertebrate pest management training. Assistance was provided to Mr. 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. Mr. Yousuf Mian, DWRC Project counterpart at the Bangladesh Agricultural Research Institute, was admitted into a graduate program in vertebrate pest management at CSU during January 1989. His research involves developing a control strategy to reduce postharvest losses to stored grain by rodents in Bangladesh. Mr. Ejaz Ahmad, former DWRC counterpart research specialist with the Vertebrate Pest Control Laboratory in Islamabad, Pakistan, between 1985 and 1991, was also accepted into graduate school in the Department of Fishery and Wildlife Biology at CSU in September 1991. His proposed research topic is "The use of biodegradable microspheres as oral vaccine carriers for rodents."

IPRS scientists participated in the "International Course on Vertebrate Pest Management with Emphasis on Needs of Developing Countries" held at Bowling Green State University, Bowling Green, Ohio, between May 20 and June 21, 1991. Mr. Lynwood Fiedler lectured on rodenticide delivery systems, Africa and Asian

rodents, damage assessment and activity indices, and environmental hazards from rodenticides; Dr. Richard Bruggers covered an introduction to quelea and bird control techniques; Dr. James Keith discussed environmental hazards; and Dr. Michael Jaeger presented information on quelea biology, bird damage assessment, and remote sensing and marking. Twelve students from Africa, Asia, the Caribbean, and the United States attended these sessions. The 12 students were from Africa (8), Asia (1), the Caribbean (1), and the United States (2).

**IPRS Awards**

On March 27, 1991, Dr. Richard Bruggers accepted on behalf of DWRC the USDA/ Office of International Cooperation and Development (OICD) 1991 group International Honors Award. OICD acknowledged DWRC/IPRS for its worldwide contribution to reducing food losses in developing countries. This is the second such recognition for DWRC, as an individual International Honors Award was given in 1989 to Mr. Joe Brooks, DWRC Project Leader in Pakistan.

On June 12, 1991, DWRC's IPRS personnel also received the USDA Award for Superior Service and the APHIS Honor Award, presented in Washington, D.C., for exceptional sustained contributions in vertebrate pest management leading to increased agricultural production in developing countries and in recognition of outstanding contributions in support of the APHIS mission of "Protecting American Agriculture."

The following IPRS publications received recent DWRC Publications Awards:

Brooks, J. E., E. Ahmad, I. Hussain, S. Munir, and A. A. Khan, eds. 1990. A Training Manual on Vertebrate Pest Management. A GOP/USAID/DWRC Vertebrate Pest Control Project, National Agricultural Research Centre, Pakistan Agricultural Research Council, Islamabad. 206 pp.

Bruggers, R. L. and C.C.H. Elliott, eds. 1989. *Quelea quelea*: Africa's Bird Pest. Oxford University Press, United Kingdom. 402 pp.

Bruggers, R. L., M. M. Jaeger, J. O. Keith, P. L. Hegdal, J. B. Bourassa, A. A. Latigo, and J. N. Gillis. 1989. Impact of fenthion on nontarget birds during quelea control in Kenya. Wildl. Soc. Bull. 17:149-160.

Jaeger, M. M. and R. L. Bruggers. 1989. Flocking and seasonal movements of *Quelea quelea* and *Agelaius phoeniceus* in relation to crop damage. Agric. Zool. Rev. 3:271-315.

Knittle, C. E., G. M. Linz, B. E. Johns, J. L. Cummings, J. E. Davis, Jr., and M. M. Jaeger. 1987. Dispersal of male red-winged blackbirds from two spring roosts in central North America. J. Field Ornithol. 58(4)490-498.

Agricultural production in Yemen is concentrated in large valleys and terraced hillsides.

High populations of the black rat (*Rattus rattus*) occur in virtually all facilities that store grain and other commodities. Rodents consume, contaminate, and destroy a large amount of Yemen's stored food resources.

Birds, which damage ripening corn, are only one of several vertebrate pests that take a heavy toll on Yemen's field crops.

Corn, wheat, and other grains are cultivated on the high central plateaus of Yemen.

**International Programs Research Section**[1]

| | |
|---|---|
| Richard L. Bruggers | Section Chief |
| Jean A. Alleman | Program Assistant |
| D. Sue Brinegar[a] | Clerk-Typist |
| Joe E. Brooks | Wildlife Biologist (Pakistan) |
| Cody M. Dusenberry[b] | Clerk |
| Lynwood A. Fiedler | Wildlife Biologist |
| Marilyn A. Harris | Editorial Assistant |
| Michael M. Jaeger[c] | Zoologist (Bangladesh) |
| Peter J. Johns | Biological Technician |
| James O. Keith | Wildlife Biologist |
| G. Keith LaVoie[d] | Wildlife Biologist |
| John E. McConnell[e] | Project Manager (Morocco) |
| J. Juan Spillett[f] | Wildlife Biologist (Chad) |

[a] Ms. Brinegar transferred to the DWRC's Administrative Office during May 1991.
[b] Miss Dusenberry, a student, worked for IPRS during the summer of 1991.
[c] Dr. Jaeger transferred to DWRC's Predator Control Research Section on June 30, 1991.
[d] Mr. LaVoie retired on May 16, 1991.
[e] Mr. McConnell worked with IPRS in Morocco between May 1, 1990, and June 3, 1992.
[f] Dr. Spillett worked with IPRS in Chad between on July 3, 1990, and December 10, 1991.

**Bangladesh (Counterpart Personnel)**

| | |
|---|---|
| Abdul Karim | Head, Division of Entomology |
| Emdadul Haque | Senior Scientific Officer |
| Parvin Sultana | Senior Scientific Officer |
| Yousuf Mian[2] | Senior Scientific Officer |
| Mosharof Hossain[3] | Scientific Officer |
| Rajat Kumar Pandit | Scientific Officer |
| Habibur Rahman | Scientific Officer |

[1] Fully funded under a Participating Agency Service Agreement (PASA).
[2] Currently involved in a graduate program at CSU.
[3] Left the Project in 1990.

**Chad (Counterpart Personnel)**

| | |
|---|---|
| Mornan Kounade[a] | Project Assistant |
| Abdelwahib Yacoub[b] | Project Assistant |
| Djibo Koulangar[c] | Project Technician |
| Dourbaga Maila[d] | Project Technician |
| N'Doubakoi Tatoloum[e] | Project Technician |
| Delassoum Richard | Driver |
| Dilemko Louis | Janitor/Rodent Control Laborer |

[a] Dr. Kounade worked with the Project from May 1990 to June 1991.
[b] Mr. Yacoub worked with the Project between October 1989 and June 1990.
[c] Mr. Koulangar joined the Project in March 1990.
[d] Mr. Maila began working with the Project during its initial stages in October 1989; he left the Project in January 1991.
[e] Mr. Tatoloum began working with the Project in October 1990; he was transferred from the Project in June 1991 to serve as "Chef de Base phytosanitaire du LAC" in Bol, Chad.

**Pakistan (Counterpart Personnel)**

| | |
|---|---|
| Abdul Aziz Khan[1] | Principal Scientific Officer |
| Iftikhar Hussain[1] | Scientific Officer |
| Shahid Munir[1] | Scientific Officer |
| Shamsul Kabir[1] | Field Assistant |
| Liaqat Ali Wahla[1] | Laboratory Attendant |
| Ejaz Ahmad[2] | Program Specialist |
| M. Munir Asif | Program Specialist |
| Liaqat Ali[3] | Program Assistant |
| Kamran Rafi | Program Assistant |
| Barbara Neilson | Executive Secretary |
| Yousaf Khan[3] | Driver |
| Raja Mohammad Nawaz[3] | Driver |
| Sheikh Talat Pervaiz[3] | Driver |
| Mohammad Hanif | Driver |
| Nasim Ijaz | Driver |
| Fateh Mohammad[1] | Driver |
| Mohammad Ilyas | Rodent Control Laborer |
| Gul Zaman Khan | Rodent Control Laborer |

[1] GOP/VPCL counterpart staff assigned to NARC.
[2] Currently involved in a graduate program at CSU.
[3] Left the project in 1990.

## PARTICIPATION in MEETINGS, CONFERENCES, and SEMINARS

Brooks, J. E. Attended the 2nd World Health Organization/APHIS "Consultation on baits and baiting delivery systems for oral immunization of wildlife against rabies," Fort Collins, Colorado. July 10-12, 1990.

Bruggers, R. L. Attended the 10th Great Plains Wildlife Damage Workshop in Lincoln, Nebraska. April 15-18, 1991.

Bruggers, R. L., L. A. Fiedler, M. M. Jaeger, and J. O. Keith. Taught classes at the "International Course on Vertebrate Pest Management with Emphasis on Needs of Developing Countries" at Bowling Green State University, Bowling Green, Ohio. May 20-June 21, 1991.

Bullard, R. W. Presented six lectures in a training course on integrated control of bird problems in agricultural crops in Argentina and Uruguay, "Curso Binacional Sobre Manejo Integrado de Aves Plaga" at Salto, Uruguay. The topics for Mr. Bullard's lectures were bird repellents and nonlethal methods of damage control as well as ecotoxicological concepts and applications. September 23-27, 1991.

Fiedler, L. A. Presented G. K. LaVoie's paper on "A study of the toxicity of the anticoagulant brodifacoum to American kestrel (*Falco sparverius*)" and offered a poster session on "Efficacy of burrow fumigation in reducing rodent activity in Philippine rice fields" (by L. A. Fiedler, M. S. Ahmed, and Z. Ya) at the 3rd International Conference on Plant Protection in the Tropics, Kuala Lumpur, Malaysia. March 20-23, 1990.

Fiedler, L. A., and M. W. Fall. Participated in an Expert Panel Meeting on Rice Rodent Control sponsored by the International Rice Research Institute, Los Baños, Philippines. Mr. Fiedler and Dr. Fall led discussions on the topics of "Rodent pest problems on experimental rice farms" and "Controlling rice losses to rodents: field, storage, research areas, and rural communities," respectively. September 10-14, 1990.

Fiedler, L. A., and G. K. LaVoie. Attended the 14th Vertebrate Pest Conference in Sacramento, California. Mr. Fiedler presented a paper entitled "Rodents as a food source." March 5-8, 1990.

Jaeger, M. M. Attended a workshop on "Sampling of biological populations and resource selection studies" at the University of Wyoming, Laramie. January 7-11, 1991.

Jaeger, M. M. Presented a paper on "Selective control of quelea populations in eastern Africa" at a conference on "Wildlife 2001: Populations" in Oakland, California. July 29-31, 1991.

Keith J. O. Presented an ecotoxicology seminar on "Specificity in pesticide use as a means of environmental protection: an example from predator control." University of California, Davis. May 1, 1990.

Keith, J. O. Submitted an abstract on bird pests that was included in the proceedings at the Caribbean Ornithological Congress in St. Lucia (Dr. Keith was unable to attend the meeting). August 4-7, 1991.

Savarie, P. J. Attended the XVII Pacific Science Congress Symposium on the Impact of the brown tree snake on the fauna of Guam in Honolulu, Hawaii. May 30-31, 1991.

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Anderson, D. W., J. O. Keith, G. R. Trapp, F. Gres, and L. A. Moreno. 1989. Introduced small ground predators in California Brown Pelican colonies. Colonial Waterbirds 12(1):98-103.

Brooks, J. E. 1990. Commensal rodents and ectoparasite control. Pages 115-122 *in* J. E. Brooks, E. Ahmad, I. Hussain, S. Munir, and A. A. Khan, eds., A Training Manual on Vertebrate Pest Management. Pakistan Agricultural Research Council, Islamabad.

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Brooks, J. E., E. Ahmad, I. Hussain, S. Munir, and A. A. Khan, eds. 1990. A Training Manual on Vertebrate Pest Management. A GOP/USAID/DWRC Vertebrate Pest Control Project, National Agricultural Research Centre, Pakistan Agricultural Research Council, Islamabad. 206 pp.

Bruggers, R. L. 1989. Assessment of bird-repellent chemicals in Africa. Pages 262-280 *in* R. L. Bruggers and C.C.H. Elliott, eds. *Quelea quelea*: Africa's Bird Pest. Oxford University Press, United Kingdom. 402 pp.

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Mullié, W. C., and J. O. Keith. 1991. Notes on the breeding biology, food and weight of the singing bush-lark *Mirafra javanica* in northern Senegal. Malimbus 13:24-39.

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Rat Facts, No. 1. The Sahel and rodents. Chad Rodent Control Research Project, N'Djamena, Chad. September 1990.

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**Trip Reports**[a]

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Brooks, J. E. 1991. Closure of Vertebrate Pest Control Project in Pakistan. Trip Report--Pakistan. 4 pp.

Brooks, J. E. 1991. Rodent control research and damage assessment activities in Chad. Trip Report--Chad. 12 pp.

Bruggers, R. L. 1989. Trip Report--Chad, Italy, and Morocco. 7 pp.

Bruggers, R. L., and M. W. Fall. 1990. Program activities, progress, and future action plans for cooperative Denver Wildlife Research Center projects in Bangladesh and Pakistan. Trip Report--Bangladesh and Pakistan. 9 pp. and 5 attachments.

[a] Trip reports are on file at the IPRS, DWRC.

Bullard, R. W. 1991. Bird pests in Argentina and Uruguay: repellent consultancy. Unpublished report prepared for the Food and Agriculture Organization of the United Nations. 22 pp. and 3 appendices.

Bullard, R. W. 1991. Bird pests in Argentina and Uruguay: second repellent consultancy. Unpublished report prepared for the Food and Agriculture Organization of the United Nations. 16 pp. and 1 attachment.

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Savarie, P. J. 1990. Rodent control research and training activities in Chad. Trip Report--Chad. 7 pp. and 1 appendix.

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**Other Reports and Documents**

Asif, M. M., S. Munir, E. Ahmad, and J. E. Brooks. 1990. Fasloon main chuhon ka tadaruk. An illustrated handbook in Urdu on rodent control in crops. Vertebrate Pest Control Project. A GOP/USAID/DWRC Project, National Agricultural Research Centre, Islamabad, Pakistan. 32 pp.

Brooks, J. E. 1990. End of Assignment Report of the Vertebrate Pest Control Project. May 21, 1990. A GOP/USAID/DWRC Project, National Agricultural Research Centre, Islamabad, Pakistan. 35 pp.

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Fiedler, L. A. Draft terminal statement of Technical Cooperation Programme, Prevention of food losses through rodent control, Eastern Caribbean. Prepared by the Food and Agriculture Organization of the United Nations, Rome, for the Governments of Grenada, St. Vincent/Grenadines, Barbados, St. Lucia, Dominica, Antigua/Barbuda, and St. Christopher/Nevis by FAO, Rome. November 21, 1989. 11 pp.

Keith, J. O., J. G. Ngondi, R. L. Bruggers, B. A. Kimball, and C.C.H. Elliott. Fenthion contamination and effects in wetland roosts treated for bird control in Kenya. Final Report. September 17, 1991. FAO Crop Protection Project, KEN/85/009, in cooperation with the National Plant Breeding Station, Njoro, Kenya. 39 pp.

Vertebrate Pest Control Project. 1991. Gharelo choohay aur un ka tadaruk. (A handbook in Urdu for rural women regarding commensal rodents and their control). A GOP/USAID/DWRC Project, National Agricultural Research Centre, Islamabad, Pakistan. 33 pp.

Vertebrate Pest Control Project. 1991. Jangli soor aur un ka insdaad. (A handbook in Urdu on wild boar, its biology and control). A GOP/USAID/DWRC Project, National Agricultural Research Centre, Islamabad, Pakistan. 21 pp.

Vertebrate Pest Control Project. 1991. Saih uskay nuqsanat aur tadaruk. (A handbook in Urdu on porcupine, their damage and control.) A GOP/USAID/DWRC Project, National Agricultural Research Centre, Islamabad, Pakistan. 13 pp.

NOTE: Further information on special reports or publications can be obtained from the authors or the agency for which the report was prepared.

## INTERNATIONAL VISITORS

| Date | Name | Representing |
|---|---|---|
| **1989** | | |
| Oct 1-Dec 9, 1989 | John Wilson | Centre for Population Management, Queensland University of Technology, Brisbane, Australia |
| Oct 1-Apr 2, 1991 | Sayed Ahmed | Bangladesh Rice Research Institute, Gazipur (Graduate student at CSU) |
| Oct | Maria Elena Zaccagnini<br>Elizabeth Aguilera-Garramuno | Argentina<br>Colombia<br>(Graduate students at CSU) |
| Oct 16 | Konrad Bogel | World Health Organization Geneva, Switzerland |
| Oct 23 | Peter Farrell | Churchill, Australia |
| Oct 23 | Valda Farrell | Lisborne, Australia |
| Nov 25-Jan 5 | Shahid Munir | VPCL/NARC Islamabad, Pakistan |
| **1990** | | |
| Jan 8-11, 1990 | Byung-Ho Yoo | Forestry Res. Institute National Ecology Res. Center Chinne City, South Korea |
| Feb 28 | Joe Crocker | ADAS, Worplesdon United Kingdom |
| Mar 12-23 | Javier Bellati | Bariloche, Argentina |
| Mar 12-13 | Peter Nelson | Wellington, New Zealand |
| Mar 13-16 | N.P.S. Chauhan<br>S. P. Goyal | Wildlife Institute of India New Forest Dehra Dun, India |

**International Visitors** (Continued)

| Date | Name | Representing |
|---|---|---|
| **1990** | | |
| Mar 19 | Herwig Leirs | University of Antwerp<br>Belgium |
| Mar 19-23 | Javier Bellati | Argentina |
| Apr 23 | Ahmad Tabell<br>Mohammed Alalimi | Yemen Ministry of<br>Agriculture |
| May 7 | El Deeb, Hassan Ibrahim<br>Hassan Abd-Allah | Harmful Animal Research<br>Department, Egyptian<br>Agricultural Research Center<br>Plant Protection Institute<br>Cairo, Egypt |
| Jul 31 | Donna Scott | American Embassy<br>Amman, Jordan<br>(transferred to La Paz,<br>Bolivia during 1991) |
| Nov 5-8, 1990<br>Feb 4-6, 1991 | Joe Kitts | Locust Coordinator, USAID<br>Rabat, Morocco |
| **1991** | | |
| May 3 | Jalil Ahmad | Agricultural and Rural<br>Development, USAID,<br>Islamabad, Pakistan |
| May 21 | Gillian Key<br>Graham Farrell | Natural Resources Institute<br>United Kingdom |
| May 22 | Fred Schaffner | USFWS, Caribbean Islands<br>National Wildlife Refuge<br>Boqueron, Puerto Rico |
| Jul 22 | Cesore di Francisco<br>Ronelle Lelli | Instituto Zooprofilattico<br>Sper., Termamo, Italy |

**International Visitors** (Continued)

| Date | Name | Representing |
|---|---|---|
| **1991** | | |
| Jul 22-24 | Ian Grant | Natural Resources Institute<br>Chattam, United Kingdom |
| Jul 26 | Mely Hoque | University of the Philippines<br>at Los Baños, Philippines |
| Jul 26 | Raimund Grau | FRG<br>Bayerswerk, Germany |
| Jul 29-31 | Ed Carroll | Land Protection Branch<br>Department of Lands<br>Queensland, Australia |
| Jul 29-Aug 2 | Thadeo M.C. Tarimo<br>(Thadeus) | Pest Control Unit<br>Arusha, Tanzania<br>(Student at Purdue<br>University) |
| Aug 5-7 | Hassan Farrag | Agricultural Research Corp.<br>Sudan, Africa |
| Aug 30 | Ejaz Ahmad | VPCL/NARC<br>Islamabad, Pakistan<br>(Graduate student at CSU) |
| Sep 3-5 | Paul Livingstone | New Zealand |
| Sep 24 | Lubos Nondek | Water Research<br>Prague, Czechoslovakia |