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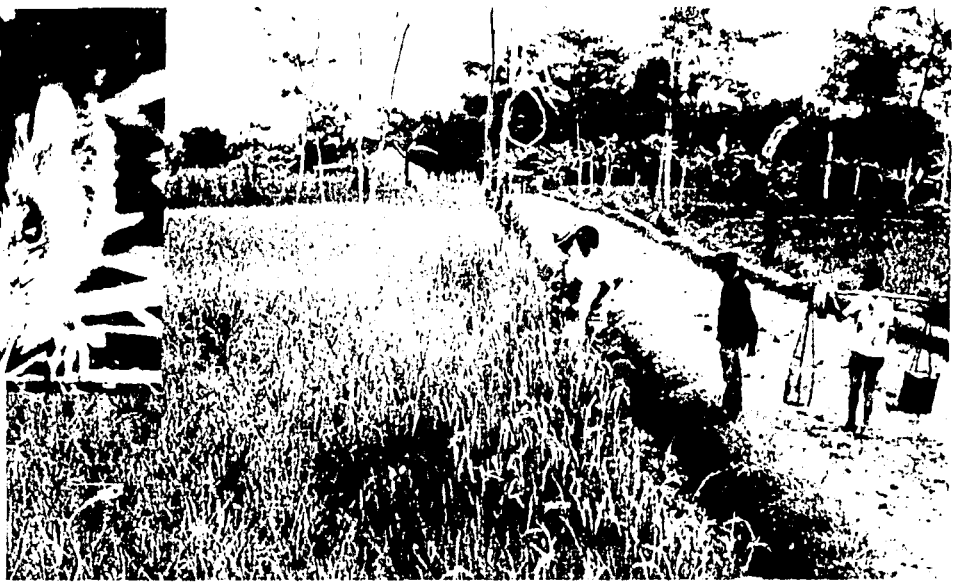
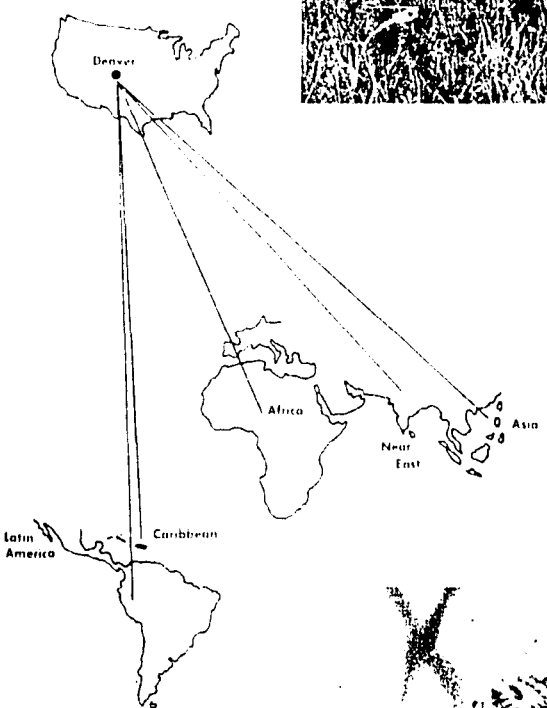
VERTEBRATE DAMAGE CONTROL RESEARCH IN AGRICULTURE

ANNUAL REPORT 1983





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

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1983 ANNUAL PROGRESS REPORT*

SECTION OF INTERNATIONAL PROGRAMS

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The cover illustrates the broad international scope of the USAID-sponsored International Programs of the Denver Wildlife Research Center (DWRC) and two of the most severe animal damage problems under investigation. Research at DWRC and in the field involves evaluating different control methods including chemical, physical, cultural, or other techniques that have potential for providing positive benefits by reducing 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 approached.

Vertebrate damage in agriculture involves a variety of crops and species of animals, primarily birds and rodents. Direct losses occur typically at planting and sprouting, during the milk or dough stages (for grains), just before harvest, or under posthavest storage conditions. Field programs are involved in trying 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 small-farm agriculture. In localized areas, rodents may be a principal factor limiting crop production; more often, rodents unobtrusively remove a share of production before harvest--crop after crop, season after season. Although there are more than 6,000 kinds of rodents, only about 50 can be considered significant agricultural pests.

Losses to birds are less well documented than those to rodents. Various species of parrots, parakeets, blackbirds, weavers, doves, seedeaters, pheasants, and waterfowl are among the types of birds known to cause damage in 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 perhaps the most important vertebrate pest species in the world.

CONTENTS

	Page
THE COVER	iii
CONTENTS	v
FRONTISPIECE	ix
INTRODUCTION	1
PROGRAM DEVELOPMENT	5
FIELD PROGRAMS	9
HAITI	9
Crop Production and Losses to Vertebrate Pests	9
Vertebrate Damage and Control in Corn	18
Protecting Corn From Bird Damage	22
Vertebrate Pest Damage to Cacao	25
Bird Damage to Experimental Sorghum Plots	25
Using Bird Netting to Protect Experimental Crops	27
Comparing Warfarin and Zinc Phosphide for Rat Control in Rice	29
Breeding Biology of Village Weavers	29
Cooperation With National and International Organizations	32
Personnel and Training	32
BANGLADESH	35
Simulated Bird Damage on Sprouting Wheat to Estimate Yield Losses	35
Repellency and Toxicity of Chemicals to Pest Birds in Bangladesh	36

BANGLADESH (cont'd) Page

Field Trials of Bird Repellents in Sprouting Wheat . 36

Rodenticide Evaluations 41

Operation OSKER 42

Simulated Rat Damage in Deepwater Rice 46

A National Campaign to Reduce Rat Damage in Wheatfields in Bangladesh 47

Jackal Damage Survey 56

Cooperation With National and International Organizations 60

Personnel and Training 60

PHILIPPINES 63

Comparing Methods for Assessing Rat Damage in Corn . 63

Feed Losses to European Tree Sparrows (*Passer montanus*) at Duck Farms 64

Evaluating Trimethacarb as a Bird Repellent 69

Efficacy of Fumigating Rat Burrows in Ricefields . . 73

Perimeter Baiting of Ricefields to Reduce Rodent Damage 74

Using Rodenticides in Tracking Grease to Control Rats in Rice 75

Cooperation With National and International Organizations 81

Personnel and Training 81

OUTREACH ACTIVITIES 83

AFRICA 83

Fluorescent Particle Markers 83

Quelea Book 88

OUTREACH ACTIVITIES (cont'd) Page

VERTEBRATE PEST PROBLEM DEFINITION 88

Pakistan 88

TRAINING 88

SUPPORTING RESEARCH 93

Rodenticide-treated Nest Material to Control *Bandicota bengalensis* 93

Blood Indices of Lithium Chloride and Correlated Taste Aversion in Wild Rats 93

Miniature Radio Transmitter Developed 94

Determining Trimethacarb Residues in Sorghum and Rice . 94

Developing Sorghums That are Less Susceptible to Bird Damage 97

Evaluating Experimental Rodenticide M&B 36,892A in Wild Norway Rats (*Rattus norvegicus*) 97

POSTHARVEST STUDIES 101

Managing Postharvest Vertebrate Pest Problems in Developing Countries 101

Stored Commodities Survey in Bangladesh 101

Postharvest Stored Food Losses on Farms and in Villages in Bangladesh 102

Rodent Damage to Stored Grains in a Village in the Philippines 107

Granary Losses of Stored Grain to Sparrows and Pigeons . 108

Estimating Postharvest Grain Losses to House Mice . . . 109

PERSONNEL 111

PUBLICATIONS 113

INTERNATIONAL VISITORS 117

PARTICIPATION IN MEETINGS, CONFERENCES, SEMINARS 119

SOLUTIONS TO PROBLEMS
DEPEND UPON KNOWLEDGE
WHICH ONLY RESEARCH
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INTRODUCTION

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.

In recent years, the role of vertebrate depredations in agriculture is attracting more interest in developing nations. Recognizing this, the U.S. Agency for International Development (USAID) has supported a research program at the Denver Wildlife Research Center of the U.S. Fish and Wildlife Service (USFWS) since 1967 under a Participating Agency Service Agreement (PASA) as provided for in Section 632B of the Foreign Assistance Act of 1961. The program goal is to evaluate these situations and, when circumstances warrant, develop methods to reduce or eliminate the damage. For many years, DWRC has been recognized as a leading organization in researching vertebrate pest damage problems and developing useful tools for vertebrate pest management. Its problem-solving team approach has led to developing and using new methods, materials, and techniques for vertebrate pest control, resulting in monetary savings in several developing countries.

The overall objective of this project is to increase the available human food supply in developing countries by reducing losses to vertebrate pests in both preharvest and postharvest situations. The ultimate aim of the 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 end result of this project. Program goals are accomplished by (1) in-country programs, (2) outreach activities from the DWRC as requested by USAID/Washington, USAID Missions, or host countries, (3) supervisory and administrative functions from DWRC and USAID/Washington, and (4) problem-oriented research activities at DWRC through the Sections of Supporting Sciences, Bird Damage Control, Mammal Damage Control, and other components of the Center. Vertebrate damage problems in Africa, Asia, and Latin

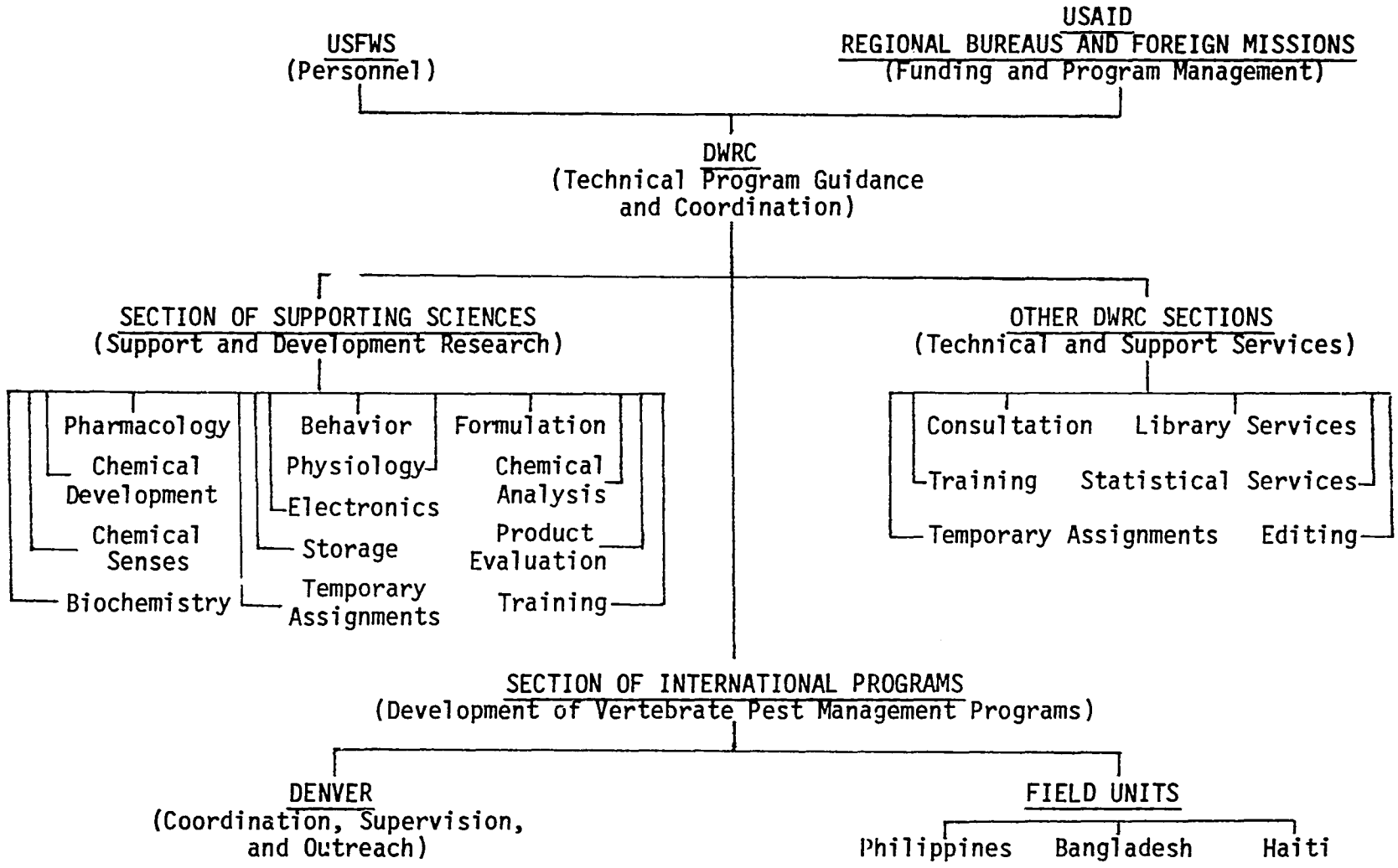
America are continuously reviewed with the aim of adapting current techniques or materials to specific problem situations in a crop protection-oriented management program which will provide an effective means of long-term crop protection.

The project incorporates a balanced but flexible program of applied research, technology transfer, and training. Research activities incorporate coordinated 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 favorable climate 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.

The Section of International Programs of DWRC provides support and direction to field personnel, assists in establishing relevant research objectives for laboratory personnel, and coordinates the team efforts of DWRC and cooperating scientists. The experienced DWRC staff is composed of specialists in diverse fields such as ecology, physiology, pharmacology, wildlife biology, nutrition, statistics, animal psychology and behavior, chemistry, and electronics. Several staff members have foreign experience and fluency in foreign languages. Denver Center laboratories are well equipped with the instrumentation necessary to conduct research in each of the disciplines involved. General administrative support is provided in the areas of fiscal management, personnel matters, commodity procurement, records management, and coordination of correspondence, reports, and manuscripts. Related activities include representing the program to other organizations, coordinating DWRC-based training for USAID participants, briefing visitors, developing cooperative programs with international organizations, providing technical information to USAID Missions or other cooperators, and assisting USAID personnel in program development and negotiations with foreign governments.

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

ORGANIZATIONAL CHART



During 1983, project personnel devoted much time and effort to support the activities of field stations and cooperate with other organizations in research and training of mutual interest. This cooperation has included work with the Food and Agriculture Organization (FAO) Regional East Africa and West Africa Quelea Projects on fluorescent marking techniques, residue analyses for crop protection trials, assistance in graduate research programs, and assistance in organizing and participating in a training workshop "Vertebrate Pests of West African Crops" held in Niamey, Niger, together with the Organization for African Unity (OAU) and USAID. Staff continued to provide program planning and technical assistance to USAID in vertebrate pest management. At the request of USAID/Pakistan, DWRC helped the Government of Pakistan assess rodent and bird problems and outline the requirements for implementing vertebrate pest management programs.

Latin America

To address the problem of vertebrate pest damage to agriculture in the Caribbean Region, the USAID Bureau for Latin America and the Caribbean and DWRC established in 1979 a regional program with special emphasis placed on those crops which are predominantly produced by traditional farmers. The project headquarters is in Port-au-Prince, Haiti, to serve the specific needs of Haiti and other regional countries.

During 1983, considerable effort was made by the DWRC Project Leader and Vertebrate Pest Laboratory staff to more completely document the vertebrate pest problem in Haiti. Crop production statistics were gathered and losses to vertebrate pests were described from questionnaire surveys or quantified from actual field assessments. Studies evaluating wrapping material, nets, and chemical repellents were initiated to protect crops from birds. Warfarin and zinc phosphide were used to protect rice from rodents. The year's activities provided excellent training and experience to the Vertebrate Pest Laboratory personnel.

Philippines

The DWRC project leader and personnel of the National Crop Protection Center (NCPC) continued to research new methods for reducing rodent damage to rice and evaluate chemical repellents for reducing bird damage to ripening sorghum. Project personnel supervised training of several graduate students in vertebrate pest management research and participated in additional workshops and extension programs. On 20 September, the project leader returned to DWRC in Denver ending 16 years of direct involvement in establishing an

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effective national center for pest control, research, and extension in association with the University of the Philippines at Los Baños. DWRC will continue to provide short-term assistance as requested.

Bangladesh

The two Bangladeshi graduate students, who received their M.S. degrees at the University of the Philippines at Los Baños in Vertebrate Pest Management and had returned to the Vertebrate Pest Control Laboratory (VPCL) in 1982, became immediately involved in an active research program. Studies were initiated to quantify wheat yield at harvest following simulated bird damage to sprouts; determine sensitivities of several bird species to chemical repellents and the toxicities of rodenticides to common rodent pests; control rodents in deepwater rice; and determine the agricultural and economic importance of jackals. In addition, a National Rat Control Campaign in major wheat-growing areas was conducted in cooperation with the Bangladesh-German (GTZ) Plant Protection Programme.

Δ Damien - Site of Field Station

HAITI

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Three field programs involving resident U.S. biologists were continued during 1983 under the USAID/DWRC program. These projects were located in Haiti, the Philippines, and Bangladesh. The broad goals of these programs are to increase food production and to reduce the risk of severe agricultural losses caused by vertebrate pests in developing countries. Specific objectives are to:

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 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.

4. Provide training at DWRC and appropriate universities to perfect capabilities of counterparts to conduct programs in vertebrate pest management.

HAITI

During 1983, vertebrate pest problems were more completely documented. Crop production statistics were gathered and losses to vertebrate pests were described from surveys or quantified from field assessments. Studies evaluating wrapping material, nets, and chemical repellents were initiated to protect crops from birds. Warfarin and zinc phosphide were used to protect rice from rodents. The year's activities provided excellent training and experience to Vertebrate Pest Laboratory personnel.

Crop Production and Losses to Vertebrate Pests

Peasant farmers constitute about 80% of the Haitian population. There are some 600,000 peasant farms ranging in size from less than one to several hectares. Farm families primarily grow crops for consumption, although often some products are sold for cash income.

Corn, sorghum, and rice are major food crops. Legumes, root crops, plantain, vegetables, and fruits are other important crops grown for food (Table 1). Sugarcane, coffee, cacao, cotton, and sesame are primarily cash crops. Ten or more different crops may be raised on small farms during the year. Some, such as corn and sorghum, may be grown on the same piece of land, but at different

seasons; others may be mixed on a single parcel during the same season. Annual plants are actively cultivated. Perennial plants such as fruits, coffee, cacao, and cotton often are scattered and receive little attention except for harvesting.

Table 1. Production of major crops in Haiti, 1979.[a]

Food crops	Production (x 1,000 mT)	Cash crops	Production (x 1,000 mT)	Fruit crops	No. trees (millions)
Corn	183	Sugarcane	5,552	Mango	4.5
Sorghum	123	Coffee	214	Orange	2.1
Rice	122	Cacao	11	Coconut	1.5
Beans	52	Cotton	6	Grapefruit	1.4
Pigeon peas	26	Sesame	4		
Peas	14				
Peanuts	24				
Banana	210				
Plantain	301				
Sweet potato	269				
Manioc	254				

[a] 1979 is the latest year for which statistics are available.

High crop yields are achieved in the rich, alluvial plains near Cap Haitien, Port-au-Prince, Miragoane, and Les Cayes. Most of the rice in Haiti is produced as a monoculture in floodplains of the Artibonite Valley. Irrigation is widely practiced only in these areas. In more arid and mountainous areas, where most peasants farm, crop diversity and yield decrease.

Because rainfall and topography in Haiti are diverse, cropping practices vary considerably. To determine where to concentrate initial vertebrate pest work, crop production data for 1979 was compiled for each of the 20 agricultural districts staffed by Ministry of Agriculture agronomists. To further facilitate program planning, a questionnaire survey of vertebrate damage in the agricultural districts was conducted. Agronomists were asked to estimate damage intensity by different vertebrates to each crop at different stages of growth and in storage. They also were asked to indicate when damage was greatest. Fourteen of 20 districts responded to the questionnaire.

In nine different crops, heavy damage by vertebrates was reported by >50% of the districts. Heavy damage to some crops was reported during all months of the year. For all crops, most districts

The Vertebrate Pest Laboratory at the Ministry of Agriculture, Haiti, was nearly completed during 1983.

reported damage at maturity (Table 2). Damage to newly planted seeds was important for corn, rice, and sorghum. Losses during storage were frequently reported only for corn.

Table 2. Magnitude of vertebrate damage to crops by growth stage, based on questionnaires of agricultural districts in Haiti.

Crops	No. districts reporting damage	% districts reporting damage at different stages			
		Seeds	Vegetative	Mature	Storage
Corn	14	93	29	100	93
Rice	12	58	8	92	0
Sorghum	13	50	0	100	8
Coffee	8	0	0	100	0
Cacao	5	0	0	100	0
Sugarcane	14	0	31	92	0
Sweet potato	13	0	15	100	8
Manioc	10	0	0	89	22
Coconut	8	0	0	100	0
Peanuts	9	25	0	100	0
Peas	13	38	31	100	0
Fruits	9	0	14	100	0
Others	13	0	10	100	10

Between 77 and 100% of the districts reported rat damage for major crops; only 25% reported coconut losses to rats (Rattus spp.; Table 3). Village weavers (Ploceus cucullatus) damaged rice, sorghum, and corn in 100%, 85%, and 57%, respectively, of the districts reporting losses. Hispaniolan woodpeckers (Melanerpes striatus), Hispaniolan parakeets (Aratinga chloroptera), and crows (Corvus spp.) damaged a variety of crops in many districts. Semi-feral dogs often were a problem in corn and peanuts.

In August 1983, farmers on 18 farms in the Cul-de-Sac Plain near Port-au-Prince were individually contacted to learn of their specific practices and problems. Farms ranged from 0.75 to 20.6 ha (average 4.5 ha) and produced 22 different crops (average 9.2 crops) (Table 4). Ten crops and several fruits were attacked by rats and birds (Table 5). Rat damage was reported in all crops, and dogs damaged corn on all farms. Damage by village weavers always was reported in sorghum. Woodpeckers, crows, and parakeets usually damaged corn; woodpeckers also damaged fruits and coconuts.

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Table 3. Principal vertebrate damage to crops in Haiti based on responses to questionnaires by 14 of 20 agricultural districts.

Crops	No. districts with crops	Districts (%) with heavy damage	Months of heaviest damage	% districts reporting damage by vertebrate pests[a]							
				Rat	Dog	VW	WP	PK	CR	GF	GQ
Corn	14	100	Apr-Jul	100	86	57	93	64	93	0	0
Rice	12	83	Jun-Dec	92	0	100	0	17	33	0	17
Sorghum	13	85	May-Jun/Dec-Jan	77	0	85	23	69	31	15	15
Coffee	8	50	Sep-Dec	100	0	0	13	0	0	0	0
Cacao	5	80	Aug-Nov	100	0	0	60	0	20	0	0
Sugarcane	14	57	Jan-Dec	100	0	0	86	7	0	0	0
Sweet potato	13	46	Nov-Apr	100	0	0	0	0	8	8	0
Manioc	10	50	Dec-Apr	100	0	0	0	0	10	0	0
Coconut	8	25	Jan-Dec	25	0	0	100	13	63	0	0
Peanuts	9	78	Jan-Dec	100	56	11	11	11	44	0	0
Peas	13	62	Dec-Feb	92	8	31	8	38	31	8	0
Fruits	9	11	Jan-Dec	89	22	11	56	33	44	0	0
Others	13	31	Jan-Dec	100	2	0	23	0	8	0	0

[a] VW = Village weaver (*Ploceus cucullatus*).
WP = Hispaniolan woodpecker (*Melanerpes striatus*).
PK = Hispaniolan parakeet (*Aratinga chloroptera*).
CR = Crows (*Corvus* spp.).
GF = Guinea-fowl (*Numida meleagris*).
GQ = Grassquits (*Tiaris olivacea*).

In Haiti, many different crops may be raised on the same small farm during the year, either during different seasons, or in mixed parcels in the same season.

Most tillable land in Haiti is under cultivation. Crops are grown in floodplain, river valleys, and on mountainsides.

Table 4. Incidence of various crops grown on 18 farms in the Cul-de-Sac Plain, Haiti, 1983.

Crops	No. farms	Crops	No. farms
Corn	18	Plantain	6
Sorghum	18	Eggplant	6
Peas	18	Peppers	5
Sweet potato	15	Tobacco	5
Sugarcane	15	Avocado	5
Tomato	14	Shallot	2
Beets	10	Chives	2
Manioc	10	Banana	1
Coconut	9	Leeks	1
Fruits	7	Taro	1
Yams	6	Cabbage	1

Table 5. Principal vertebrate damage to crops on 18 farms, Cul-de-Sac Plain, Haiti, 1983.

Crops and commodities	No. farms with crops	% farms reporting damage by various pests[a]							
		Rat	Dog	VW	WP	PK	CR	SA	GQ
Corn	18	100	100	50	67	83	44	50	0
Sorghum	18	39	0	100	17	44	28	33	11
Peas	18	83	0	0	0	0	0	0	0
Sweet potato	15	67	0	0	0	0	0	0	0
Sugarcane	15	80	0	0	33	0	0	0	0
Tomato	14	14	0	0	0	0	0	7	0
Beets	10	20	0	0	0	0	0	0	0
Manioc	10	70	0	0	0	0	0	0	0
Coconut	9	11	0	0	78	11	44	22	0
Fruits	7	71	0	0	86	0	14	0	0
Plantain	6	83	0	0	17	17	0	17	0
Seeds	18	11	0	0	6	0	6	6	0
Farm animals	18	17	6	0	0	0	0	0	0
House	18	17	0	0	0	0	0	0	0
Storage	18	56	0	0	0	0	0	0	0

[a] VW = Village weaver (*Ploceus cucullatus*).
WP = Hispaniolan woodpecker (*Melanerpes striatus*).
PK = Hispaniolan parakeet (*Aratinga chloroptera*).
CR = Crows (*Corvus* spp.).
SA = Smooth-billed ani (*Crotophaga ani*).
GQ = Grassquits (*Tiaris olivacea*).

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Loss of newly sown seeds to rats, woodpeckers, and crows was mentioned as was the problem of rats and dogs killing farm animals. Ten farmers reported rat damage to stored corn. These surveys provided a good basis for establishing priorities for vertebrate pest activities in Haiti.

Vertebrate Damage and Control in Corn

In Haiti, damage to corn by rats and birds can be severe. A 1982 study near Port-au-Prince showed yield losses of 5.6% to rats and 8.1% to birds. In another study at Damien, yield losses to rats ranged from 5.6 to 12.1% in 11 varieties of experimental corn. In 1982 and 1983, additional data on vertebrate damage to corn were obtained by quantifying damage incidence.

Rat (*Rattus* spp.) damage to corn was relatively low between July 1982 and August 1983 (Table 6). These findings were consistent with trapping and damage data in other crops. However, rat damage in corn was extensive during December 1983.

In 1983, warfarin in a ground corn bait was exposed for 6 weeks or more before harvest in four cornfields. Bait (0.025% warfarin) was placed in PVC pipe stations, 50.8 cm long x 7.62 cm wide. Baiting did not appreciably reduce rat damage to corn (Table 6). Domestic chickens, particularly chicks, fed on baits. Bait station design must be improved to exclude chickens.

To test bait preference, a commercially prepared warfarin bait and warfarin in ground corn were exposed in alternate stations in one field. Average corn bait consumption (317 g/station) was three times that of commercial bait (93 g/station).

The incidence of ears damaged by village weavers and woodpeckers was much higher in the Les Cayes area and at Damien than in Fond des Negres and Cul-de-Sac Plain. This could result from differences in habitat, bird populations, corn availability, and feeding preferences. The Cul-de-Sac Plain is arid and not particularly good habitat for either species. Village weavers were seldom seen at Fond des Negres; woodpeckers were abundant but had more alternate foods there than in other areas. Good habitat tends to provide food for rats and birds and to buffer crops from damage. But during periods of food scarcity, such as the winter dry season, damage to crops in good habitats may be high. Other work, specifically measuring woodpecker damage to corn near Les Cayes, illustrated this apparent influence of habitat quality. Damage ranged from 0 to 38% in 10 fields scattered throughout the plains and foothills. Woodpeckers were present at all sites, but other factors evidently influenced their use of and damage to cornfields.

Peasant farmers constitute about 80% of the Haitian population. Farm families primarily grow crops such as corn, sorghum, rice, legumes, plantain, fruits, and vegetables for food, but some products are sold at markets for cash income.

Table 6. Vertebrate pest damage to corn in Haiti.

Location and date[a]	No. ears examined	Percentage of ears: No damage	Damage by: Rats	Village weavers	Woodpeckers
Les Cayes					
Jul 1982	2,380	44.2	0.8	15.1	39.9
Damien					
Feb 1983	100[b]	0.0	0.0	40.0	33.0
Apr 1983	210	28.6	1.9	12.8	56.7
	227	14.1	0.4	52.0	33.5
Aug 1983	100	53.5	4.2	9.5	32.8
	400	47.7	5.8	6.0	40.5
Dec 1983	100	35.0	18.0	20.0	27.0
Fond des Negres					
Jul 1983	400	85.0	2.2	3.3	9.5
	1,500	87.7	2.7	1.9	7.7
Cul-de-Sac Plain					
Jul 1983	100	96.0	0.0	0.0	4.0
	300	91.7	0.3	1.7	6.3

[a] Where two assessments are shown from the same location on the same date, the first assessment was in corn where sustained baiting with warfarin was used to control rats. The second assessment was in corn without rat control.
[b] An additional 27% of these ears were damaged by both bird species.

Damage to corn by woodpeckers and village weavers was especially high during the dry season in February at Damien (Table 6), where the incidence of bird damage to 50 ears that were undamaged when marked on 26 January was 33% on 31 January, 48% on 11 February, 69% on 24 February, and 100% at harvest. Of 100 ears examined after harvest, 33% had only woodpecker damage, 40% had only village weaver damage, and 27% had been attacked by both species. In this field, woodpeckers began feeding on corn when ears first developed, 3-4

weeks before flowering. At milk stage, village weavers began eating corn and continued until harvest. On 27 January, an 8% solution of 4-Aminopyridine was brushed onto a small area of exposed kernels on 20 ears scattered in the field. The typical distress symptoms elicited by this chemical were observed in affected village weavers during the next several days, but other village weavers feeding in the corn and nearby sorghum did not react and continued to feed. In other species, individuals in 4-AP stress effectively frighten and disperse flocks from the area.

Protecting Corn From Bird Damage

Experimental corn plots at Damien often receive heavy damage from woodpeckers and village weavers. Several wrapping materials were tested as a means of reducing this damage in a maturing cornfield during July and August.

Four samples of 24 corn ears were each wrapped with one of the following materials: burlap, woven plastic cloth, heavy nylon netting, and dried banana leaves. The four wrapping materials were alternately used to wrap selected ears along four rows in a cornfield. Wrappers remained on ears during the 4-week vulnerable period before harvest. Ninety-six unwrapped ears were marked and left exposed to serve as references. Only undamaged ears were selected for wrapping or marking.

Only nylon netting provided adequate protection from birds. It also provided more continuous coverage of ears than other wrappers. With rain, burlap absorbed moisture and tended to gather at the base of ears. The plastic and banana leaf covers often tore during high winds. The incidence of bird damage varied from 4% for ears covered with nylon netting to between 13 and 21% for ears covered with the other materials; 19% of the uncovered ears were damaged (Table 7). Only woodpeckers attacked the wrapped or marked ears; no damage by village weavers was found. Wrappers that left a substantial percentage of ears uncovered did not protect corn; bird damage to those ears was almost the same as to uncovered ears.

Table 7. Protection offered by four materials wrapped around ears of corn.

Wrapping material	No. ears	Weekly avg (% of bare ears)	Cumulative woodpecker damage (% of ears)
None	96	100	19
Burlap	24	22	21
Woven plastic	24	32	13
Nylon netting	24	4	4
Banana leaves	24	33	17

Netting is used to protect high-value research crops from birds in many countries.

Just before harvest, vertebrate damage was measured throughout the field. The incidence of damaged ears was 4% for rats, 10% for village weavers, and 33% woodpeckers. Bird damage was higher throughout the field than in the area where wrappers were tested. These results possibly suggest that the presence of markers and wrappers may have deterred village weavers and woodpeckers from the area.

Vertebrate Pest Damage to Cacao

In Haiti, cacao is often an important cash crop for peasant farmers. Small, scattered plantations are attacked by rats (*Rattus rattus*) and woodpeckers, but the extent of damage has not been quantified. Although cacao is harvested year-round, a minor production peak occurs in November-December, and a major one in April-July.

At the Fond des Negres Experiment Station, rat and woodpecker damage to harvested pods was recorded weekly between 22 April and 16 July. Because many damaged pods spoiled on trees and were not harvested, damage figures represent only part of the loss. Of 980 harvested pods, 509 (52%) were undamaged, 218 (22%) were damaged by rats, and 253 (26%) were damaged by woodpeckers. Forty-eight percent of the harvested pods had been damaged by vertebrates. Woodpecker damage in Haiti was much higher than in the Dominican Republic, where surveys found average woodpecker damage of 3.7% in 1980 and 3.5% in 1981.

On 22 July, 100 undamaged cacao pods on trees in the Fond des Negres plantation were marked and numbered to determine the damage pattern of a group of undamaged, ripening pods. Each week during the next 5 weeks, the condition of marked pods was recorded. Twenty-nine percent of the marked pods were damaged in 5 weeks; 9.5% by woodpeckers and 19.5% by rats (Table 8). Ten pods disappeared, and their loss probably represented additional damage by woodpeckers and rats. Vertebrate damage was less during July and August than between April and July. Rat damage to harvested pods was similar during the two periods, but woodpecker damage was much less in August, suggesting that birds fed more on other foods in August. Both surveys indicated that rat and woodpecker damage to cacao probably was of economic importance, and that additional work is needed to determine how damage affects yields and profits, and how losses can be reduced.

Bird Damage to Experimental Sorghum Plots

Native, rainfed sorghum in Haiti is harvested in December, whereas irrigated, hybrid sorghum matures in July. Fortunately, sorghum seldom matures during the dry season (November-March) when relative food scarcity for birds exists. At the Damien Experiment Station, experimental sorghum consistently suffers heavy bird damage during

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Table 8. Incidence of vertebrate damage to 100 marked cacao pods, Fond des Negres, Haiti.

Pod location	No. pods	No. pods undamaged	No. pods damaged	
			Woodpeckers	Rats
On trees	38	24	7.5[a]	6.5[a]
Harvested	52	41	1.0	10 0
Unknown[b]	10	6	1.0	3.0
Total	100	71	9.5	19.5

[a] One pod had both woodpecker and rat damage. One-half pod was added to each category.
[b] Damage recorded until pods disappeared.

winter. On 12 November 1982, sorghum was planted for a varietal trial in a 1,500-m^2 plot; plants began flowering in early January. About 1 week after flowering, yellow-faced grassquits (*Tiaris olivacea*) began to attack developing heads. They fed on the seeds for only about 10 days before leaving the field. Subsequently, village weavers appeared in the field and fed on sorghum until it was harvested 7 weeks later. Efforts were made to measure damage and reduce losses to birds in this field.

Sorghum was sprayed with trimethacarb, a chemical being evaluated as a bird repellent, on 26 January at a rate of 3.0 kg/ha. Grassquits had ceased feeding in the field by that time. Trimethacarb did not repel village weavers; their numbers were as high 2 days after its application as they were before treatment (Table 9). On 28 January, 4.5 kg/ha of methiocarb were applied to the sorghum. The incidence and size of village weaver flocks diminished during the next week. Later, bird numbers again increased in the field, and methiocarb (4.5 kg/ha) was applied weekly until harvest.

Two approaches were used to assess bird damage to sorghum during this study. One hundred undamaged heads among all 37 varieties in the field were marked on 25 January and later checked just before harvest. In addition, damage on all heads within each of four varieties was assessed on 25 January and again at harvest. During each assessment, a visual estimate was made of the proportion of seeds on each eaten head. These proportions were averaged for all sampled heads. On 25 January, damage to the four varieties ranged from 14.1 to 64.6% (Table 10). This damage was largely caused by grassquits. At harvest, damage to these same sorghum heads averaged between 43.1 and 78.3%. The additional loss primarily was due to

Table 9. Average numbers of birds in a sorghum field sprayed with chemical repellents at Damien Experiment Station, Haiti.

	Avg no. birds						
	January				February		
Bird species	17-25	26[a]	27	28[b]	29 Jan-4 Feb	5[b]	6-7
Grassquits	75	5	0	0	1	0	0
Village weavers	30	15	14	38	9	150	50

[a] Trimethacarb application of 3.0 kg/ha.
[b] Methiocarb application of 4.5 kg/ha.

Table 10. Bird damge to sorghum varieties, initially by yellow-faced grassquits and, thereafter, by village weavers, Damien Experiment Station, Haiti.

Varieties	Damage (%) Initial	Final	Difference
Sepan 80-38	14.1	43.1	+29.0
D 71448	49.3	61.2	+11.9
Sepan 77	23.0	64.7	+41.7
HL 2	64.6	78.3	+13.7

village weavers. Repellents did not protect sorghum from village weavers. However, this sorghum matured at the end of the dry season, when other foods were scarce. Also, the repellents were not applied before damage started, and it is more difficult to deter birds once their feeding habits are established.

Although birds ate 40% or more of the seeds produced by these four sorghum varieties, they showed marked preferences among the other varieties in the field. Some varieties were not eaten, while others were almost totally consumed. Initial damage estimates indicated that birds, primarily grassquits, preferred varieties D 71448 and HL 2. Final damage, mostly contributed by village weavers, suggested that the latter species preferred the varieties Sepan 80-38 and Sepan 77. Bird damage to sorghum is an important problem in Haiti, and methods must be developed to protect fields.

Using Bird Netting to Protect Experimental Crops

Sorghum losses to birds can exceed 50%, and often more than one-half of the ears in cornfields have some bird damage. Light-weight

netting was used to cover small sorghum fields and reduce damage by village weavers, woodpeckers, and grassquits at the Damien Experiment Station. Netting is expensive but practical to protect high-value crops. Birdnet (OV 1670), a plastic netting produced by the Conwed Corporation, was selected for these initial trials because of relative cost, light weight, durability for repeated use, and the fact that birds do not become entangled in the net, which is important with respect to nonpest species.

In August and November, nets were suspended over two sorghum fields at Damien. Additional, uncovered sorghum fields were not available for comparison. Birds had begun to feed in both fields before nets were set up. Nets effectively excluded birds and eliminated further damage.

Considerable work was required to prepare the nets. The net was 4.3 m wide, so that several pieces had to be overlapped and secured with twist locks to form a net of sufficient width to cover fields. Although this netting was light, it was difficult to suspend tightly over fields. Light ropes were used to support netting between 2.4-m wooden poles placed about 30 m apart. This support structure was not entirely satisfactory and would be impractical to cover fields larger than 0.25 ha or to protect crops taller than 2.1 m.

Cost of netting varied from US \$0.09 to \$0.18 per m^2 depending on quantity purchased. For plots >0.65 ha, costs are \$0.09/m^2. In Haiti, other materials and labor raised costs to about \$0.10/m^2 or \$1,000/ha (Table 11). This cost can be amortized over several cropping seasons by repeated use of netting. Tests are now needed to determine how many times netting can be used before it deteriorates.

Table 11. Costs (US \$) of materials and labor for covering a 1,600 m^2 field with netting in Haiti.

Item	Unit	Unit cost	No. units	Total cost
Netting	m^2	0.09	1,600	144.00
Poles	ea	0.30	9	2.70
Pole ties	ea	0.18	9	1.62
Twist locks	ea	0.05	168	8.40
Labor	man-h	0.50	12	6.00
Total				162.72[a]

[a] Costs are approximately \$0.10/m^2.

Bird netting is practical only in specialized situations such as in small rice seedbeds or seed multiplication plots. In addition, netting often will be justified in crop research because experiments are costly and results should not be compromised by extraneous factors such as bird damage.

Comparing Warfarin and Zinc Phosphide for Rat Control in Rice

In Haiti, rat control campaigns in rice with zinc phosphide have traditionally been organized and subsidized by the Ministry of Agriculture, but such efforts have not been assessed to determine benefits in terms of increased rice yields. In 1983, costs and benefits of rat control in rice with warfarin and zinc phosphide were compared. The study was conducted at Trois Bornes, Artibonite Valley. Eight 1-ha plots, each containing 20 paddies, were selected, and rice was transplanted into fields in mid-January. All plots were at least 200 m apart. Warfarin and zinc phosphide treatments were assigned at random. In four plots, warfarin bait (0.025% warfarin in ground corn) was exposed in five bait stations/ha from the second week of February until early April. Zinc phosphide bait (1.0% zinc phosphide in ground corn) was exposed in four plots on 7 March. About 350, 40-g zinc phosphide bait packages were placed along paddy dikes in each plot. Rice was harvested in mid-April.

In early February, 18 snap traps were set for 2 nights in each plot. An average of 2.4 rats (*Rattus norvegicus*) per plot were captured; 13 house mice (*Mus musculus*) were also caught. In mid-March, only three rats and four mice were caught using the same trapping effort.

Rat damage, based on the proportion of uncut and cut tillers in 1,000 randomly selected hills/plot just prior to harvest, was low, averaging 0.9% (range 0.1-1.6%) on warfarin plots, 1.3% (range 0.8-1.7%) on zinc phosphide plots, and 1.8% (range 1.6-2.1%) on untreated fields.

Warfarin applications cost $7.40/ha, whereas the single zinc phosphide treatment costs $2.84/ha. By extrapolating yields from the treated and untreated fields, a cost:benefit ratio of about 1:2 was obtained for warfarin and 1:3 for zinc phosphide. However, such comparisons may be misleading under conditions of low rat populations and minimal damage.

Breeding Biology of Village Weavers

In Haiti, village weavers often feed on rice, corn, and sorghum. Damage varies with season and location. Knowledge of the species' behavior is essential for understanding its damage pattern and for developing methods to reduce these losses.

Males completed prenuptial molt and began visiting old colony sites in early March. Birds were feeding on rice, the only grain crop available at this time, and supplemented this diet with insects. At night, birds congregated into large roosts. The first nesting colonies formed in mid-April. Observations were made at 43 colonies between Les Cayes and the Artibonite Valley. Thirty of these colonies formed during late April and persisted until June or early July, but five others were active until early September. The remaining eight colonies did not form until late July or August and lasted until early September. From these general observations it seemed that throughout southern Haiti there was an early reproductive period (May-June) in which many birds participated, and a later, shorter nesting period with fewer birds.

For 10 colonies near Damien, information was obtained weekly on total number of nests, number of new, green nests, number of males, females and juveniles seen, bird behavior, and general colony characteristics. At the peak of colony development, males chased and fought with each other, built new nests, and displayed to entice females to accept nests. Females were not obvious when incubating eggs in nests and were difficult to count during forays to obtain food for young. Fledged young were conspicuous but hard to count because they constantly moved in and out of colonies. Birds usually ranged only about 1 km from colonies while feeding or gathering nest material.

These 10 colonies were established in five different tree species (Table 12). Only one tree species was used in each colony, but nests were built in from one to six individual trees.

Greatest number of nests in colonies varied from 37 to 240 around villages and from 145 to 468 in more open country. Greatest concentration of nests was on the Shada farm, a sisal plantation surrounded by dry acacia woodlands.

Nesting was not synchronous among breeding colonies. At the airport colony, females arrived in May, produced young, and dispersed, all within a period of about 1 month. Males occupied trees and built nests until late June, but they did not attract additional females. In contrast, at Flag new females arrived during several months and males continued to build new nests until early August.

Nestlings were first present in early colonies between 19 May and 11 June. In late colonies, most young hatched in mid-August. Fledglings appeared in June in early colonies and in the last half of August in late colonies.

The intensity of damage to crops by village weavers seems to be much less during the reproductive season. In some colonies in the Artibonite Valley, birds fed heavily on nearby rice, but such crops were

Table 12. Comparison of early and late village weaver breeding colonies near Port-au-Prince, Haiti, 1983.

Colonies	Trees: Species[a]	Trees: No. with nests	Period of green nests	Date and (greatest number) of: Nests	Date and (greatest number) of: Males	Date of first: Nestling	Date of first: Fledgling	Remarks
Early								
Airport	Flamboyant	4	19 May-23 Jun	16 Jun (80)	11 Jun (20)	19 May	16 Jun	Wasps
Flag	Bayahonde	1	19 May- 4 Aug	11 Jun (240)	8 Jul (29)	26 May	23 Jun	-
Radio station	Bayahonde	1	19 May-21 Jul	23 Jun (90)	26 May (28)	3 Jun	8 Jul	Wasps
15 km	Acacia	1	19 May-15 Jul	3 Jun (145)	19 May (35)	3 Jun	23 Jun	Wasps
Gate	Acacia	3	19 May- 8 Jul	3 Jun (160)	3 Jun (40)	19 May	23 Jun	Wasps
Shada N	Acacia	2	3 Jun-15 Jul	11 Jun (300)	11 Jun (60)	3 Jun	23 Jun	Wasps
Shada SW	Bayahonde	1	3 Jun-21 Jul	23 Jun (350)	23 Jun (35)	11 Jun	8 Jul	-
Late								
Airport	Australian pine	1	29 Jul- 9 Sep	9 Sep (37)	9 Sep (15)	No data	12 Aug -23 Sep	-
Gas station	Chene	1	12 Aug-23 Sep	23 Sep (81)	26 Aug (18)	No data	26 Aug	-
Shada SE	Bayahonde	6	21 Jul- 9 Sep	9 Sep (468)	9 Sep (68)	12 Aug	26 Aug	Wasps

[a] Flamboyant (*Delonix regia*); Bayahonde (*Prosopis juliflora*); Acacia (*Acacia lutea*); Australian pine (*Casuarina equisetifolia*); Chene (*Catalpa longissima*).

seldom present within the foraging range of most colonies. Insects seemed to be the major food fed to nestlings. Birds dispersed after young fledged and attacked ripening crops over a much larger area. Thus, during the postreproductive season greatest damage can be expected from village weavers.

Cooperation with National and International Organizations

Throughout the year, staff cooperated closely with district offices of the Ministry of Agriculture, especially the Fond des Negres, Les Cayes, and Port-au-Prince districts. Field trials and demonstrations were conducted with the Organisation pour le Developpement de la Vallee de l'Artibonite (ODVA), and extension personnel of ODVA received training in rat control by project personnel.

In December, project staff assisted the Mennonite Economic Development Associates, Inc. (MEDA) in evaluating rat damage to their cacao plantations.

Project staff assessed rat and bird damage and evaluated control methods on experimental crops established by Texas A&M University at Damien. This cooperation provided some protection for their experimental crops and convenient plots for research by project staff. In addition, Dr. R. Chad Roberts was hired as a consultant by the USAID/Texas A&M project to work with the Vertebrate Pest Laboratory on the woodpecker problem.

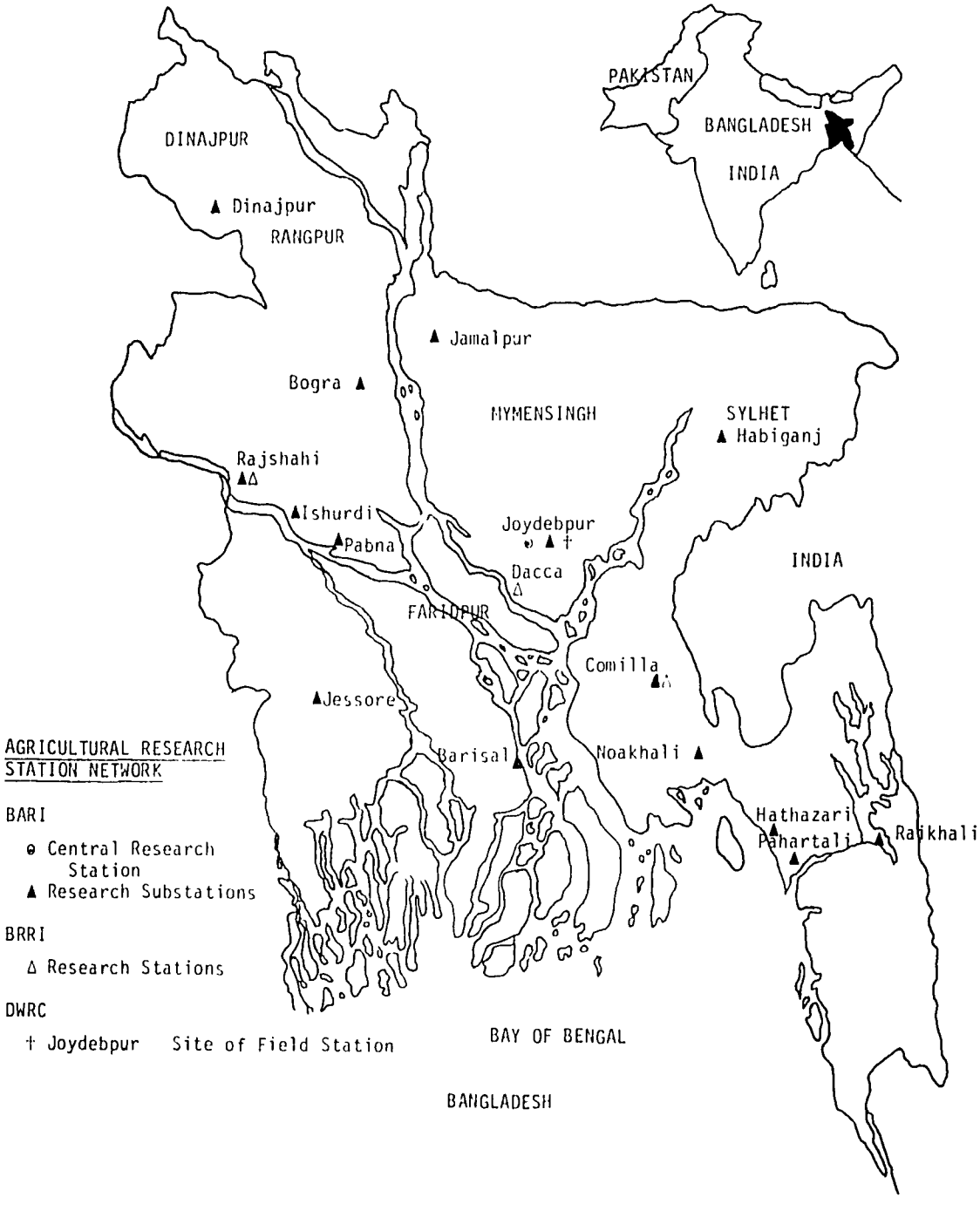
Communication was maintained with staff of the Ministry of Agriculture in the Dominican Republic regarding techniques to assess bird damage.

A proposal was developed requesting a Peace Corps volunteer to work on small-farm projects, and assistance was provided to a Peace Corps volunteer, formerly stationed in the Dominican Republic, to prepare a report on woodpecker damage in cacao.

Training and Personnel

Two students of the Faculty of Agronomy at Damien were hired during the summer to gain experience in vertebrate pest research and damage assessment. One student was assigned to Fond des Negres, the other to Cul-de-Sac Plain to assist in field trials.

Daniel Isidore, ODVA, received training in rat damage control by project personnel. He assisted project staff during training sessions with rice farmers in the Artibonite Valley where techniques of sustained baiting were demonstrated.



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Simulated Bird Damage on Sprouting Wheat to Estimate Yield Losses

Rock doves (*Columba livia*), pied mynas (*Sturnus contra*), common mynas (*Acridotheres tristis*), house sparrows (*Passer domesticus*), jungle crows (*Corvus macrorhynchos*), and house crows (*C. splendens*) attack wheat seed immediately after sowing and at the sprouting stage. These birds may remove as much as 50% of the wheat sprouts from some fields. The objective of this study was to determine the wheat yield following different damage levels (0, 15, 30, and 50%) to the wheat sprouts.

A 10 x 10-m (100 m^2) experimental plot at the Bangladesh Agricultural Research Institute, Joydebpur, was divided into 16, 2 x 2-m (4 m^2) subplots, which were again subdivided into 1-m^2 subplots. After sowing, the field was covered with a net for 15 days to protect it from bird damage. A randomized complete block design was used to assign damage levels. This resulted in a design with 16 replications of the four damage intensities. Within each subplot, the total number of sprouts was counted and the appropriate number corresponding to the particular damage level was randomly removed 10 days after sowing. At maturity, each subplot was harvested and wheat was sundried for 2 days, threshed, and weighed.

No significant difference ($P < 0.05$) in yield occurred between the undamaged and 15 % damage level (Duncan's Multiple Range Test; Table 13), probably due to tiller compensation. Yield in plots with 30 and 50% damage was significantly less ($P < 0.05$) than yield in undamaged plots. No significant differences in yield occurred among 15, 30, and 50% damage levels.

Table 13. Harvest yield of wheat after simulated bird damage to sprouts, Joydebpur, Bangladesh, 1983.

Damage level (%)	Production (g/m^2) (n=16) Total	Average*	% loss from untreated
0	4,821	301.3^{a}	0.0
15	4,442	277.6^{ab}	7.9
30	4,127	257.9^{b}	14.4
50	3,904	244.0^{b}	19.0

*Significant differences exist only between those treatments with different superscripts.

Significant differences ($P > 1.0\%$ ANOVA) occurred among replications, probably due to an uneven distribution of sown seeds and different soil moisture.

Wheat sprout loss in previous field trials in Bangladesh has averaged about 41% less in repellent-treated plots than in untreated plots. This field experiment demonstrates that, despite the high percentage of sprouts removed, plants show compensatory growth. An average sprout loss of 41% could be expected to cause about 17% less grain yield at harvest.

Repellency and Toxicity of Chemicals to Pest Birds in Bangladesh

Birds damage cereal grain crops in Bangladesh. Rock doves, common mynas, pied mynas, house sparrows, and jungle crows (*Corvus macrorhynchos*) damage wheat. Rose-ringed parakeets (*Psittacula krameri*) and jungle crows are pests of maize and sunflower. Mannikins (*Lonchura* spp.) and Baya weavers (*Ploceus philippinus*) can inflict heavy damage on maturing millet, rice, and sorghum.

Chemical repellents are used to discourage pest birds from feeding upon various crops. These repellents are applied at concentrations that normally do not cause mortality. Because these concentrations may vary considerably according to chemical and bird species, it is essential to determine the sensitivity of each chemical for the particular pest species.

The R50 concentrations of methiocarb, trimethacarb, and copper oxychloride for rose-ringed parakeets, house sparrows, mannikins, and rock doves were determined in the laboratory using standard methods (Table 14). Birds were most sensitve to methiocarb and least sensitive to copper oxychloride. The LD50 values were determined by stomach gavaging the respective chemicals. Avitrol (4-Aminopyridine), a distress-producing chemical used to frighten social birds away from food crops, was very toxic to all species. Methiocarb also was toxic in small doses especially to mannikins; trimethacarb was the least toxic. The toxicity of copper oxychloride was not determined, but data from pesticide handbooks indicate it should not cause mortality at the doses used.

Although birds were less sensitive to copper oxychloride at concentrations of 0.5 to 2.0% as a seed dressing on wheat, it has demonstrated effectiveness in field trials in Bangladesh. It is also locally available and inexpensive ($2.20/kg). In comparison, methiocarb costs about 20 times more when shipped to Bangladesh.

Field Trials of Bird Repellents in Sprouting Wheat

Methiocarb (0.25%) and copper oxychloride (0.5% and 1.0%) were applied to wheat seed before sowing at BARI research stations in Bogra and Dinajpur. Four plots, measuring 30 x 30 m and separated from each other by at least 40 m, were sown in identical manner at

Parakeets damage sunflower, maize, rice, and wheat in Bangladesh and nearby countries of Pakistan and India.

Seed treatments with chemical repellents have reduced bird damage to newly sown wheat in Bangladesh.

Table 14. Sensitivity (R50 and LD50) of several chemicals used as bird repellents to pest birds in Bangladesh.

Species	R50 (% concentration)			LD50 (mg/kg)		
	Methiocarb	Trimethacarb	Copper oxychloride	Methiocarb	Trimethacarb	Avitrol
House sparrow	0.11	0.22	0.50	14.1	33.6	5.0
Mannikin	0.05	0.15	0.50	3.5	23.8	2.0
Rose-ringed parakeet	0.18	0.34	0.47	7.9	11.9	3.1
Rock dove	0.16	0.11	0.42	5.6	67.1	2.5

each station. Wheat sprouts were counted between 15 and 30 days after sowing. Yield was obtained at harvest. Bird observations were made at Dinajpur. The species seen in the trial plots included common mynas, pied mynas, bulbuls (Pycnonotus cafer), and white wagtails (Motacilla alba). This is the first reported occurrence of bulbuls and white wagtails in sprouting wheat, but they may not have been causing damage.

Fewer seeds were eaten in the plot that had been sown with 1% copper oxychloride-treated seed than in any of the other plots (Table 15). Methiocarb and copper oxychloride (0.5%) seemed to protect seeds about equally. However, at both trial sites, the yield was not as great in methiocarb-treated (0.25%) plots as in copper oxychloride-treated (0.5%) plots (Table 16).

Table 15. Mean no. exposed wheat seeds/m^2 (± SD) removed by birds at Dinajpur, Bangladesh, 1982. Data based on average of four trial plots.

Treatment (% concentration)	Date of seed counts 3 Dec 1982	8 Dec 1982	% loss
Copper oxychloride (1.00)	25.5 ± 10.8	13.5 ± 7.9	39.2
Copper oxychloride (0.50)	44.1 ± 10.4	10.1 ± 7.0	77.1
Methiocarb (0.25)	35.4 ± 8.1	8.8 ± 4.9	75.1
Untreated	27.7 ± 11.4	3.6 ± 4.6	87.0

Table 16. Yield data and wheat sprout counts at experimental, chemically treated fields at Bogra and Dinajpur Agricultural Research Stations, Bangladesh, 1983.

Location Treatment (% concentration)	Sprout counts/m^2	% increase from reference	Yield (mT/ha)	% increase from reference
Bogra				
Methiocarb (0.25)	104.3	+84.0	1.64	+10.8
Copper oxychloride (0.5)	97.3	+71.6	1.84	+24.3
Copper oxychloride (1.0)	79.5	+40.2	0.94	-36.5
Untreated	56.7	-	1.48	
Dinajpur				
Methiocarb (0.25)	241.3	+22.2	4.32	+ 5.6
Copper oxychloride (0.5)	265.6	+34.5	4.79	+17.1
Copper oxychloride (1.0)	220.4	+11.6	4.58	+12.0
Untreated	197.5	-	4.09	-

Rodenticide Evaluations

Several rodenticides were evaluated in the laboratory for possible use in food crops in Bangladesh. This evaluation established the toxicity (LD50) of the material against common rodent species, determined mortality rates in no-choice feeding tests, and determined consumption and mortality in free-choice feeding tests.

Three materials, M&B 36,892, EL-614 (bromethalin), and coumatetralyl (Racumin^R) were evaluated. Chronic and acute toxicity data obtained with M&B 36,892 on the lesser bandicoot rat (*Bandicota bengalensis*) and the greater Indian bandicoot rat (*B. indica*) indicated that this compound was not useful as a rodenticide against these two rat species. Gavaged doses as high as 200 mg/kg and 400 mg/kg failed to kill animals. The only sign of toxicosis was temporary body weight loss in some animals. When the compound was offered at 0.18% in free-choice food baits for 4 nights, two of ten *B. bengalensis* died.

EL-614 looked more promising. This material was offered free-choice at a 0.005% concentration in the standard bait mixture of wheat flour, crushed rice, and 2% soybean oil. In one test, 10 *B. bengalensis* (five of each sex) were given the rodenticide bait and plain bait for 4 nights. Six additional *B. bengalensis* (three of each sex) also were similarly tested. Consumption of the rodenticide bait was adequate in both trials (Table 17). The average time to death was 4.2 days for females and 6.2 days for males.

Table 17. Mean daily consumption of treated (EL-614) and untreated bait, active ingredient and subsequent mortality of *B. bengalensis*. EL-614 (0.005%) was offered for 4 nights.

No. rats	Sex	$\bar{x}$ weight (g)	$\bar{x}$ daily consumption of bait (g) With poison	$\bar{x}$ daily consumption of bait (g) Without poison	$\bar{x}$ intake of a.i. (mg/kg)	Mortality
5	F	162.4	1.7	3.0	2.1	5/5
5	M	229.6	4.0	5.5	3.6	4/5
3	F	102.6	1.6	1.9	3.1	3/3
3	M	164.1	3.3	3.4	4.1	3/3

Coumatetralyl is registered in Bangladesh and will be marketed by Bayer as a ready-to-use bait in early 1984. The finished bait will contain 0.0375% coumatetralyl, as recommended by the manufacturer worldwide and will be the first anticoagulant bait available to Bangladeshi farmers. These baits were offered free-choice for 1 and 2 nights and subsequent mortality was recorded for a 15-day period. Four of the six rats that fed on coumatetralyl for 1 day died; all six rats that were given feed for 2 days died within 6 days. Mean intake of active ingredient at 1 day was 10.1 mg/kg and at 2 days 19.9 mg/kg. In a no-choice test with the same bait, mortality was 100% at both 1- and 2-day feeding (n = 12).

Operation OSKER

Operation OSKER (One Square Kilometer Eradication of Rats) was an attempt to eliminate rats from 1 km^2 of deepwater rice to demonstrate the logistical feasibility of such an effort and the practical application to reducing rat damage. Two deepwater rice areas, about 1 km^2 each, were selected in Tangail District. One area served as reference and the other was treated with 0.005% brodifacoum rat bait cakes. The untreated area was characterized by winter crops of wheat, potato, melon, and monsoon crops of deepwater rice and jute. The treated area was characterized by irrigated rice in winter and deepwater rice in the monsoon.

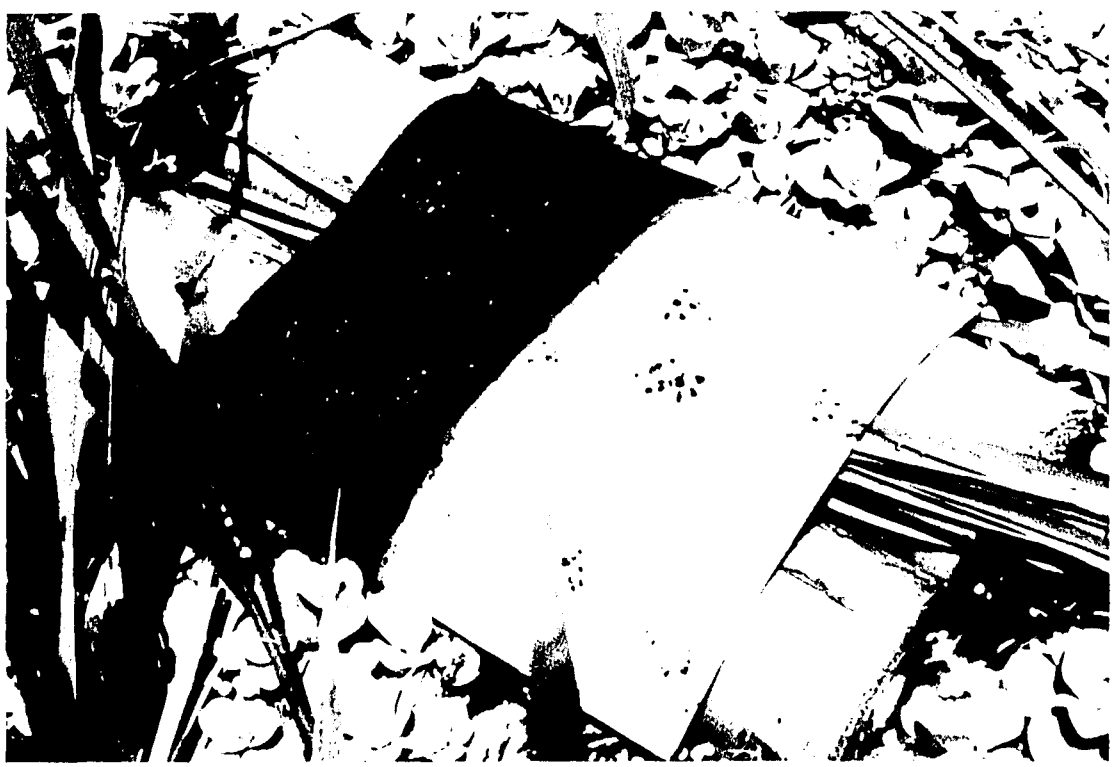
Rat activity on roadways and high ground around villages was quantified, using inked tracking tiles and burrow counts before and after baiting. Baits were applied in fields, along roadways, and in and around houses on island/villages on four occasions: 16-18 August, 30 August-1 September, 11-13 September, and 23-24 October.

Activity in the treated area was reduced 85.5% by late September following the three poison applications. Likewise, the number of rodent burrow systems decreased 90.3% in the same period, compared to only 9.8% decrease in the untreated area (Table 18).

Nine hundred seventeen 50-g bait packets were used in the treated area during the four applications; 331 in island/villages, 350 in fields, and 236 on high ground and roads. The total cost for the operation was $126 (bait = $76, labor = $50) or $1.26/ha.

The principal rat in deepwater rice was *B. indica*. This rat was found in ricefields as far as 500 m from the nearest high ground during peak floods. It began cutting rice stems at the tillering stage and constructed nests and daytime resting platforms from the cut stems. This species was relatively easy to poison by placing baits on mats of emergent vegetation or on platforms of banana plants.

It often is necessary to assess rodent damage in deepwater rice to evaluate the effectiveness of control efforts.



Inked tracking tiles, placed on pieces of banana stalk, can be used to measure rodent activity in deepwater rice.

Table 18. Rat activity based on tracking tile use and number of burrow systems in treated and untreated deepwater rice, Tangail District, Bangladesh.

Period	Area	% tiles positive			Avg activity (%)	No. burrow systems		
		Island	Field	Road		Island	Field	Road
Jun (preflood)	Treated	21.7	3.3	0.0	8.3	8	4	0
	Untreated	31.7	41.7	8.3	27.2	14	22	0
Aug (flood)	Treated	33.3	5.0	58.9	31.1	20	0[a]	93
	Untreated	66.7	3.3	20.0	30.0	24	0[a]	68
Sep (peak flood)	Treated	6.7	6.7	0.0	4.5	6	0[a]	5
	Untreated	41.7	10.0	53.3	35.0	24	0[a]	59
Nov (harvest)	Treated	6.7	6.7	1.7	5.0	2	0[a]	2
	Untreated	25.0	3.3	13.3	13.9	13	9	25

[a] Fields flooded.

Yield data were collected from comparable rice varieties from each area by clipping five 1-m^2 samples of panicles in each field. The panicles were dried, threshed, and weighed. Weight was corrected for moisture content using 12% moisture as a standard. Yield was between 41 and 124% greater in the treated area than the untreated area for the four varieties of rice that were grown in both areas (Table 19). Although some yield differences between the two areas could have resulted from soil fertility differences and farmer inputs, most of this increased yield resulted from effective rodent control.

Table 19. Yield (g/m^2) of four varieties of deepwater rice in two areas of Tangail District, Bangladesh, November 1983.

Variety	No. fields sampled (treated and untreated)	Mean yield (g/m^2) Untreated	Treated	% yield increase treated/ untreated
Injal degha	14	120.5	196.9	+ 63.4
Chamhara	16	150.0	336.1	+124.1
Channa baoalia	2	103.6	220.5	+112.8
Baron baoalia	2	133.1	188.8	+ 41.8

Simulated Rat Damage in Deepwater Rice

Deepwater rice is attacked by rats from tillering to harvest, a period often lasting up to 120 days. Losses of 5-70% have been assessed in deepwater ricefields during several seasons. Damage inflicted in the late growth stages has the most severe impact upon yield because the rice plant does not have sufficient time for compensatory growth. The objective of this study was to determine the impact on yield at harvest of cutting rice stems at different growth stages.

The study was conducted on a 12 x 29-m (348 m^2) experimental plot at Gazaria Upazila. Subplots (1 x 2 m) were established in the experimental plot. Damage levels of 0, 5, 10, 20, and 40% of total stems in each plot were simulated by cutting the appropriate number of stems during preflood, peak flood (cutting 5 cm above the water surface), and postflood (flood receding) periods (Table 20). These periods corresponded to tillering, peak stem elongation, and flowering growth stages. All subplots were harvested, sun-dried, threshed, and weighed.

Table 20. Effects of simulated rat damage on deepwater rice yield, Gazaria Upazila, Bangladesh.

Damage level (%)	Grain yield (mT/ha)		
	Tillering* (preflood)	Stem elongation* (peak flood)	Flowering* (flood receding)
0	3.64^{Ba}	3.80^{Aa}	3.75^{ABa}
5	3.41^{Ab}	2.81^{Bb}	2.78^{Bb}
10	3.31^{Ab}	2.80^{Bb}	2.67^{Bb}
20	3.17^{Ac}	2.55^{Bc}	2.30^{Cc}
40	3.11^{Ac}	2.30^{Bd}	1.55^{Cd}

*Significant differences exist between those treatments with different superscripts. Capital letters denote statistical difference within each treatment; small letters denote statistical difference within each stage.

Rat damage to deepwater rice must be controlled before full stem elongation of plants to allow satisfactory growth compensation. The closer to maturation that rat damage occurs in deepwater rice, the more severe the effect will be on yield. Twenty percent damage during the period of full stem elongation (peak flood) and flowering (flood receding) resulted in a yield loss of 33-38%; 40% damage resulted in 39-59% yield loss, respectively. Stems cut at full elongation produced panicles with only 65 grains; panicles on uncut stems averaged 204 grains. Panicles of stems cut at flowering averaged only 42 grains compared to 210 grains/panicle for uncut stems. One hundred percent of the grains remained unfilled on panicles cut at the flowering stage, while only 17.1% of the grains remained unfilled on uncut stems.

A National Campaign to Reduce Rat Damage in Wheatfields in Bangladesh[a]

Before 1978, very little was known about rodent problems in agriculture in Bangladesh. With the advent of two projects, one financed by USAID (within the Bangladesh Agricultural Research Institute, BARI) and one by the Federal Republic of Germany (within the Division of Plant Protection), both commencing in 1978 after a lengthy

[a] Much of this report has been extracted from a report by Heimo Posamentier (June 1983) entitled "Preliminary Report on the Evaluation of the National Rat Control Campaign in Wheat 1982/83 Season."

period of multilateral planning, a considerable amount of information has been gathered on the biology, ecology, and behavior of rodents important to agriculture. This information has led to useful recommendations and methods for rodent control.

The information and methods derived from various research studies were incorporated into a national rat control campaign in wheat in 1982-83. Committees were set up to guide the activities. The campaign was a joint cooperative effort between USAID/DWRC and the following groups:

1. Bangladesh-German Plant Protection Programme (Vertebrate Pest Control Section);

2. Bangladesh Department of Agricultural Extension (Field Services Division, Plant Protection Division and Agricultural Information Service);

3. Bangladesh Agricultural Research Institute, Vertebrate Pest Research Laboratory (VPRL); and

4. FAO Project, Strengthening of Agricultural Extension.

Wheat farmers were the target group in this campaign. Efforts were concentrated in the 11 primary wheat-growing districts, covering 91% of the wheat-growing areas in Bangladesh. Lesser inputs were given to the 10 secondary districts.

The campaign objectives were to:

1. create awareness, mainly among farmers, of serious rat problems;

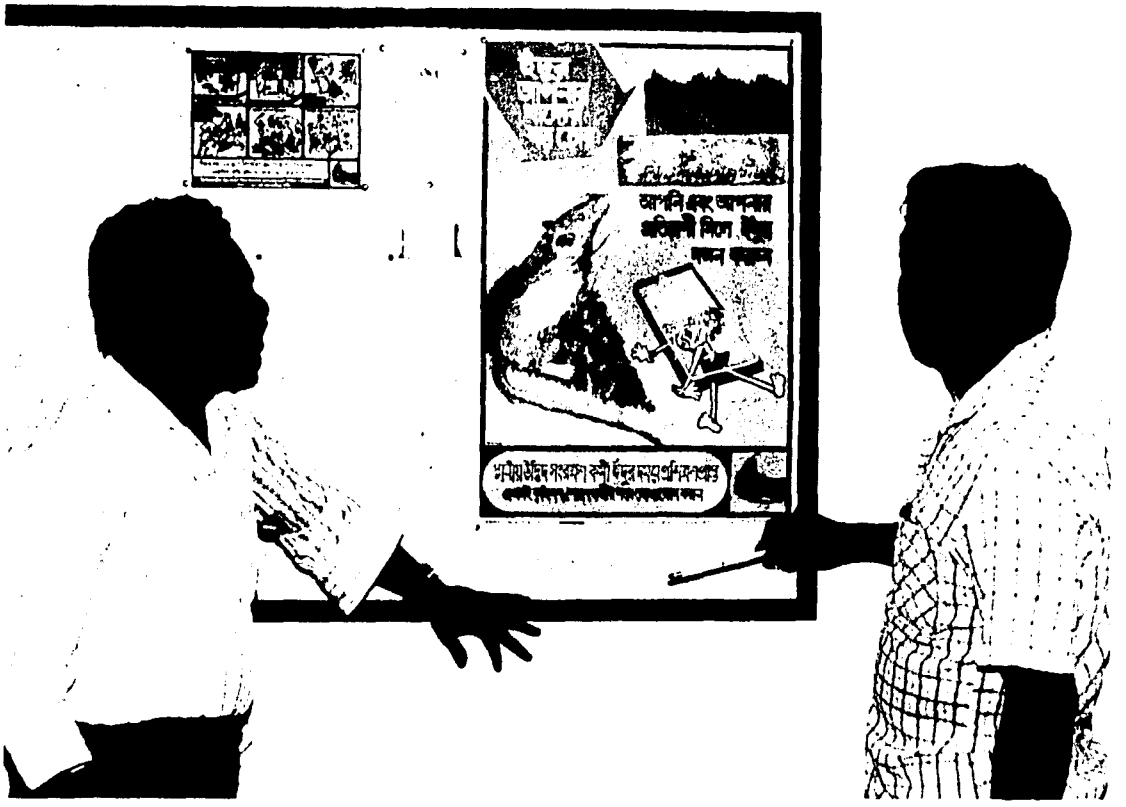
2. motivate farmers to carry out rat control in wheatfields;

3. inform farmers and government agricultural officials of effective rodent control methods;

4. familiarize farmers and manufacturers with a cheap, effective, ready-made bait; and

5. reduce the damage level in standing crops and particularly in wheat.

The campaign used all available mass media (radio, television, farmers' journals, newspapers, posters, instructional leaflets, school comics) and the respective agricultural extension staff (Table 21; Fig. 1). Posters, leaflets, comics, and bait packets were distributed in each district by agricultural extension staff after receiving a 1-day training course. The media materials and bait packets were further distributed to the village level. Bait



Many different media, including information posters, were used to create awareness of the National Rodent Control Campaign in Bangladesh.

packets (weighing 50 g) consisted of 2% zinc phosphide, crushed rice, wheat flour, and soybean oil, were cut into sun-dried bisquit-size pieces and labeled with instructions for use and precautions.

Table 21. Media distribution in primary and secondary districts.

Description	No. distributed to Primary districts	Secondary districts	Total
Motivational poster	15,000	10,000	25,000
Instructional poster	15,000	-	15,000
School comic	375,000	-	375,000
Instructional leaflet	100,000	15,000	115,000
Rodenticide packets	80,000[a]	-	80,000

[a] No. bait packets distributed through Plant Protection Division and Vertebrate Pest Research Laboratory, BARI. At least another 140,000 were distributed by pesticide dealers directly.

Additional activites included a national essay-writing competition for school children to motivate farmers via their children. A television documentary about the campaign was shown in mid-March 1983. A logo with the words "Stop the menacing rats now" was used on all campaign media materials.

Before the campaign, the recommended bait formulation was not commercially available in Bangladesh. During the campaign, the private bait producers were licensed to formulate and sell this material. Eighty thousand bait packets were formulated and produced under the supervision of the Bangladesh-German Plant Protection Programme and the Vertebrate Pest Research Laboratory, BARI. The three formulators distributed another 140,000 packets. Bait packets sold for about 10¢/packet. One bait packet was assumed to be sufficient for two average-size fields.

The effectiveness and benefits of the campaign were evaluated by staff of the Plant Protection Division and the Vertebrate Pest Research Laboratory, BARI, using a management monitoring survey to check on general campaign activities and a damage assessment survey to quantify damage in ripening wheatfields. This survey was designed to delineate the type and effectiveness of rat control practiced in wheatfields, to determine if farmers increased control activities in their wheatfields from the previous year, and to

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estimate the amount of standing wheat saved due to the campaign. A total of 851 plots in 10 districts was sampled for rat damage and 603 farmers were interviewed about control activities between March 10-31. Additional surveys were conducted by all Plant Protection Inspectors and by an independent group of experienced surveyors to establish how many farmers had been reached and motivated to conduct rat control and by what means.

The campaign was well executed by field staff and well received by farmers. Most of the materials were distributed to all levels on or before the opening ceremonies on 17 January 1983. Motivational posters, radio broadcasts, and ready-made poison bait packets were considered the best form of media.

About 108 ha were sampled for damage in the 851 plots (Table 22). Plot size averaged 0.13 ha, so that about 0.02% of the total wheat-growing area in 1981-82 was sampled. Damage (% of cut to total tillers) averaged 2.2% (Table 22). Damage in plots treated with ready-made bait was lower than in plots treated with other poisons (Fig. 2). In 1982/83, the number of farmers practicing rat control was three times greater in the primary districts and twice as great in the secondary districts than in 1981/82.

Of the farmers who did rat control in the primary districts, the majority (67%) used the ready-made bait, while 29% used other poisons and 27% relied on traditional physical methods (digging, trapping, flooding, and others). Some farmers used combined methods.

Eighteen percent of the plots surveyed had been treated with bait packets, indicating that between 750,000 and 800,000 plots were treated. Because two or three plots easily can be treated with one bait packet, at least 250,000-400,000 packets must have been used by farmers at a cost of $22,417. In addition, the Bangladesh-German Plant Protection Programme and the Vertebrate Pest Research Laboratory contributed a total of $15,000 for campaign activities. The extrapolated value of the wheat saved equaled $524,375, giving a cost:benefit ratio of the overall campaign of 1:14 (Table 23). If the bait formulation had been available to every farmer, the savings in standing wheat alone would have been more than three times the amount estimated. Surveys during previous years have indicated higher average damage (12.1%) and that year-to-year uncontrolled damage is highly variable. Rodent control techniques not only reduce damage, but also reduce risk of heavy damage.

Figure 1. School comic used in National Rat Control Campaign in Wheat.

Table 22. Avg field size and rat damage to wheat in the primary and secondary campaign districts, and percentage of farmers conducting rat control in wheat, Bangladesh, 1981/82 and 1982/83.

District	No. fields sampled	Avg field size (ha)	% rat damage	Total no. farmers interviewed (1983)	% farmers conducting control 1981/82	% farmers conducting control 1982/83
Primary						
Tangail	100	0.19	1.2	81	10	53
Pabna	109	0.14	4.6	77	0	13
Faridpur	100	0.13	1.2	34	15	56
Dhaka	91	0.14	5.1	45	11	31
Comilla	140	0.10	1.1	106	12	36
Rangpur	81	0.10	1.7	81	1	17
Dinajpur	75	0.10	1.6	75	17	32
Secondary						
Barisal	55	0.17	3.1	31	23	39
Noakhali	65	0.09	0.5	38	0	5
Jamalpur	35	0.08	2.0	35	20	46
Total/Avg	851	0.13	2.2	603		

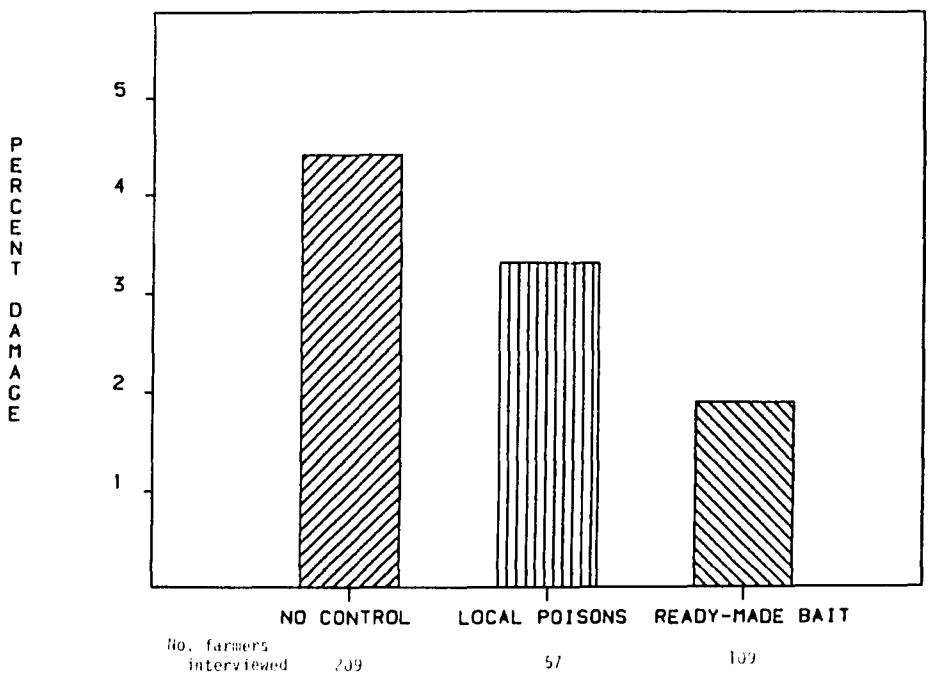

Figure 2. Comparison of % damage to wheatfields of 375 farmers using different methods of rodent control in Bangladesh, during 1982/83.

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Table 23. Savings through the use of ready-made zinc phosphide bait (R/M bait) in standing wheat in 11 primary districts in Bangladesh, 1982/83.

		Tons
Total wheat production, 1981/82		952,110
Production in primary districts only (91% of total)		866,420
Production in rat-infested plots (70% of total)		606,494
Production in plots treated with R/M bait (29% of infested fields; 109 out of 375)		175,883
Loss at 4.44% (if untreated)		7,540
Loss at 1.97% (if treated with R/M bait)		3,345
Production saved through R/M bait application		4,195
US $ saved through R/M bait application (at $125/ton)	524,375	

Jackal Damage Survey

Farmers' interviews regarding the agricultural and economic importance of jackals (*Canis aureus*) were completed in four of ten districts that will be surveyed. One hundred farmers were randomly surveyed in each district.

The importance of the jackal in the agricultural economy of Bangladeshi farmers is emerging (Table 24). Jackal predation on livestock, particularly chickens, goats, and ducks seems widespread. Damage to food crops such as sugarcane, corn, rice, jute, jackfruit, and melons can be serious for individual farmers. For example, the loss in one sugarcane field that was >60% damaged by jackals, was valued at $240.

Two hundred and twenty (54.0%) farmers reported jackal problems. Most reports of jackal damage occurred in Jamalpur (66%), Pabna (63%), and Rangpur (46%) districts. The average losses for the 401 farmers interviewed was about $8.00/year, representing $96 million/year for the 12 million farmers in Bangladesh. The average loss of chickens/farmer was 1.7 chickens/year, or about 20 million chickens/year for the whole country. This represents between 20 and 25% of the entire chicken population of Bangladesh. It can be

Jackals were reported by most farmers responding to questionnaires as important pests to livestock, melons, sugarcane, and corn in Bangladesh.

concluded from this preliminary analysis that the losses due to jackals on food crops and livestock in Bangladesh are severe, and a definite economic drain to be dealt with.

Table 24. Food crops and livestock reported by 401 farmers as damaged by jackals and estimated losses in Bangladesh.

Food crops or livestock damaged or attacked	No. farmers reporting damage	Estimate of losses (US $)
Food crops		
Sugarcane	54	1,674
Rice	12	136
Jackfruit	11	47
Watermelon	10	88
Jute	9	37
Wheat	4	19
Maize	2	34
Pineapple	2	9
Gourd	2	5
Tobacco	1	8
Lentil	1	4
Potato	1	2
Sweet potato	1	-
Total	110	2,063
Livestock		
Chickens	147	679
Goats	57	479
Ducks	19	54
Pigeons	3	6
Calves	1	16
Total	227	1,234
Grand total	337	3,297

Cooperation with National and International Organizations

The USAID/VPRL supplied CARE with 1,000 rat bait packets (2% zinc phosphide), posters, and farmers' leaflets for use in controlling rat damage to wheat in Dhamrai Upazila. Farmers enthusiasticly used the bait and requested more than CARE was able to supply.

Technical advice, traps, and rodenticide baits were provided to the British Overseas Development Agency/Bangladesh Rice Research Institute (BRRI) to protect experimental plots of deepwater rice in Mirzapur and Joydebpur.

The VPRL again cooperated with the Directorate of Agricultural Extension Services and the Bangladesh-German Plant Protection Programme in planning, training, implementing, and funding the National Rat Control Campaign in Wheat carried out in 11 districts in Bangladesh.

Cooperative studies in deepwater rice and farm storage losses of paddy were carried out with the Division of Entomology at BRRI, Joydebpur. Cooperative studies also were outlined and methodologies reviewed with the FAO/BRRI project on postharvest storage losses of paddy at farm and village level.

Personnel and Training

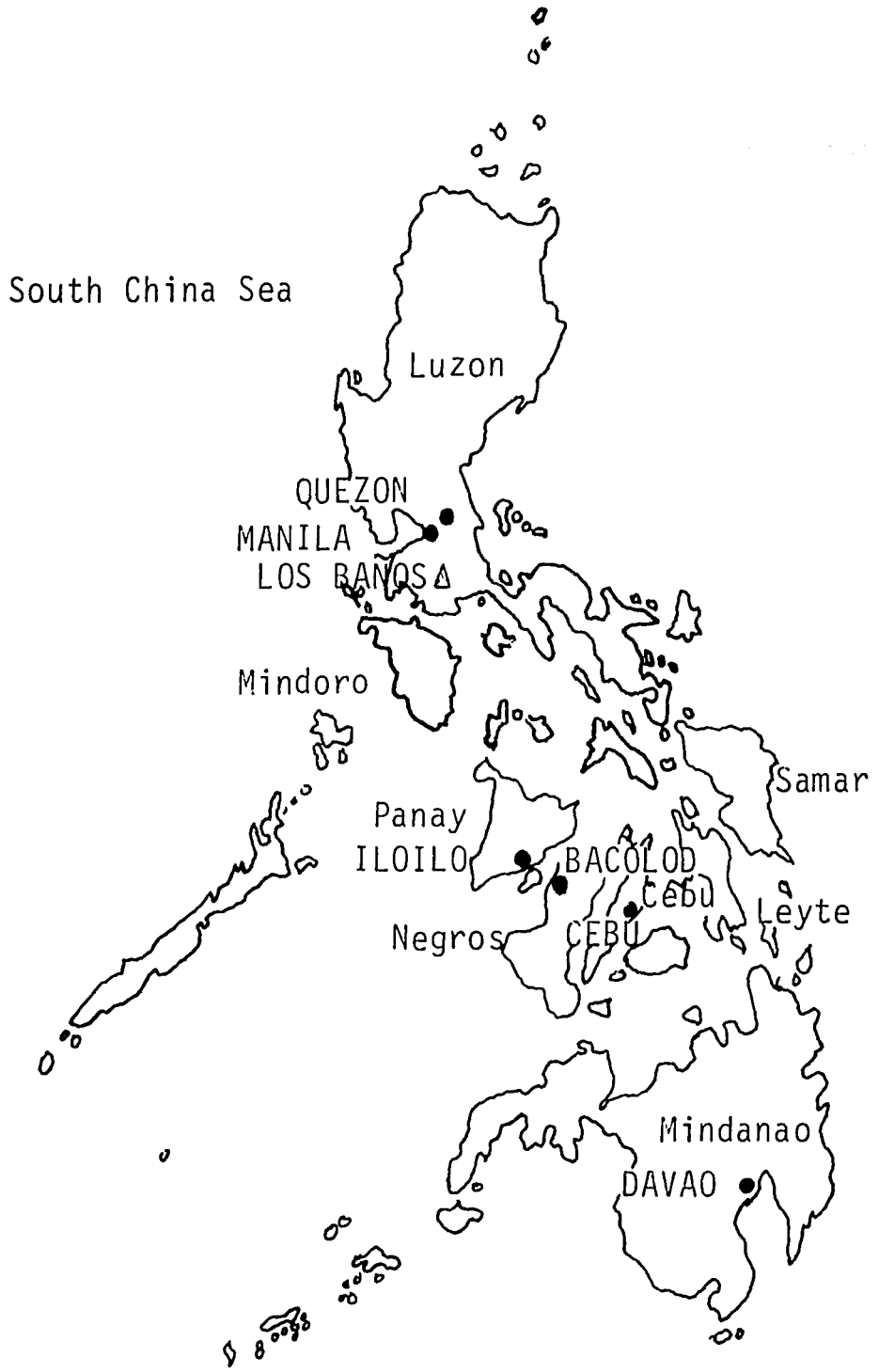
Mrs. Parvin Sultana began M.S. degree studies at Colorado State University, Fort Collins, Colorado in March 1983. Mrs. Sultana will research pest bird problems and crop protection methods for her degree in Vertebrate Pest Management.

Dr. Abdul Karim completed his Ph.D. degree at Bowling Green State University, Bowling Green, Ohio, in August 1983 and returned to the VPRL in September 1983.

Two new Scientific Officers (SO), Mr. Rajat Kumar Pandit and Mr. Shahabuddin Ahmad, both graduates of Bangladesh Agricultural University, were appointed to the VPRL in September 1983.

Rodent control training was provided to about 80 Plant Protection Inspectors, Plant Protection Assistants, and Extension Officers in connection with the National Rat Control Campaign in Wheat.

Dr. Abdul Karim, Director of Entomology, BARI, former counterpart to the Vertebrate Pest Research Laboratory, Bangladesh, in his office.



Δ Los Baños - Site of Field Station

THE PHILIPPINES

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Comparing Methods for Assessing Rat Damage in Corn

Many factors are involved in selecting appropriate techniques to assess and quantify rat damage in corn. For small research plots, very precise, often laborious methods are necessary. However, for national damage assessments, practical, rapid, yet relatively accurate methods are needed. The objective of this study was to compare the accuracy and time involved among three methods of assessing rat damage to corn (variety DMR-2).

Damage was assessed by examining 5% of 50,000 hills in a 2.5-ha field in Bukidnon Province, Mindanao. Damaged ears were measured for length of damage and total ear length. Damage was characterized as circular (when it circled the ear) or strip (when it extended vertically). The area damaged was computed on the basis of a 4-cm width for strip-type damage. Regression equations were used to convert damaged area to yield loss.

Three sampling techniques were evaluated: (1) random sampling of 50 hills in 50 rows; (2) systematic strip sampling of 1 x 5 hills sampled in an evenly distributed manner so that 40 hills per randomly sampled row were examined; and (3) stratified quadrat sampling of 5 x 5 hill quadrats randomly located within three strata--the outer 20 rows on each side and the middle. The number of quadrats in each strata was in the ratio 1:4:1.

Using the three methods, damage ranged from 12.2 to 17.3% of the total number of hills sampled, or 8.1 to 11.6% of the total ears sampled (Table 25). Yield loss varied from 51.0 to 80.4 kg/ha among the three methods. The random and systematic strip methods produced similar results. The stratified quadrat method resulted in more damaged ears, and those ears sampled had more damage.

The systematic strip method was the fastest. The other methods took longer to complete data sheets (row counts, number of randomly selected ears, transcribe data) and to examine ears.

In previous work, stratified, random sampling of 5 x 5 quadrats gave the most accurate damage estimates, yet, required the most time. Random and systematic strip methods probably underestimate actual damage. Because cornfields usually show clumped, peripheral rat damage, a method incorporating stratification, with a larger proportion of samples in outer rows and quadrats to account for clumping would be preferred. By locating the quadrat systematically rather than randomly, less time is consumed in laying out the sampling scheme as well as on the actual samples. For extensive damage surveys, the sampling time for each field should not exceed 1 h. Total man-hours can be reduced with experience and a sample size of $\leq$1% of the hills.

Table 25. Comparison of three sampling techniques to assess rat damage, grain loss, and time spent in assessing a 2.5-ha field of maturing corn in Kulasihan, Lantapan, Bukidnon, Philippines.

Parameter	Sampling method		
	Random	Systematic strip	Stratified quadrat
Total no. hills	50,000	50,000	50,000
No. hills sampled (5%)	2,500	2,500	2,500
% hills with damage	12.6	12.2	17.3
Total no. ears (1.5 ears/hill)	75,000	75,000	75,000
No. damaged ears	315	305	433
% ears damaged	8.4	8.1	11.6
Total damaged ears (Total ears x % damage)	6,300	6,075	8,700
Mean loss/ear (g ± SE)	21.1± 0.9	21.0±0.8	23.1±0.9
Total loss (kg) (Total damaged ears x mean loss/ear)	132.9	127.6	201.0
Total loss (kg/ha)	53.2	51.0	80.4
Man-hours spent sampling			
Preparing data sheets	7	1	3
Counting rat damage	16	3.5	13
Total	23	4.5	16

Feed Losses to European Tree Sparrows (*Passer montanus*) at Duck Farms

Duck farming occurs throughout the Philippines. The popularity of duck eggs to Filipinos is evident at bus stops, restaurants, and street corners. Large egg-processing facilities purchase fresh eggs from many small duck farms and commercially produce three main types

In the Philippines, duck farmers at both private and commercial farms are concerned about the amount of duck feed consumed by tree sparrows.

of eggs: "balut" (an embryo-bearing boiled egg), "penóy" (an unfertilized, hard-boiled egg), and "itlog na pulá" (a salted, unfertilized, red egg). A typical duck farm has between 400 and 1,000 ducks which are fed soaked, unhulled rice (sometimes cooked), supplemented with either snails, small bivalves, small fish, or shrimp. This feed is distributed two or more times daily in containers or on the ground, where European tree sparrows (Passer montanus) gather to feed on it. Duck farmers estimated a daily loss of 6-10 kg rice to as many as 2,000 birds. The concerns of duck farmers in the Los Baños area over the amount of duck feed eaten by European tree sparrows prompted this study.

Four duck farms near Malinta and Mayondon, Laguna Province, were selected and sparrow populations were estimated by making counts several times per day for 2-4 days each month from May 1982 through June 1983. Birds observed within each farm area were counted once each hour for 3 consecutive hours in the morning and afternoon. To determine movements of birds among the four farms, 146 birds were mist-netted at Farm I and marked with plastic leg streamers. Marked birds were recorded at each farm during the population counts and for several days immediately following banding.

To estimate the amount of food taken by sparrows, 250 g soaked, unhulled rice were exposed in each of three feeding platforms at Farm I. Ducks were excluded from the feed. The number of sparrows feeding at 5-min intervals during 30-min periods was recorded. The average consumption/sparrow/30 min was calculated.

Last Perch Trap^R, Rid-A-Bird^R perch, and commercial bird trappers were evaluated as methods of reducing the sparrow populations.

An average of 124 birds/count were observed at Farm I, and between 25-53 birds/count at the other farms during the 14-month study period (Fig. 3). Bird numbers never approached those reported by the farmers at any time during this study. The number of feeding birds was lowest at all farms during November and December, probably a result of the birds feeding on spillage in nearby harvested ricefields.

Only a small percentage of the birds in the area visited the duck farms. Of the 146 tagged birds, only a few were resighted at the selected farms.

The average amount of rice taken (eaten, spilled, and wasted) during the 30-min exposure periods at Farm I was 3.3 + 0.8 g/bird. Based on about 5 h of cumulative daily feeding activity per bird, and the average of 124 birds, about 4 kg/day of rice were eaten by sparrows. Estimated losses at the other three farms averaged 0.5-1.0 kg/day. Assuming 1 kg of soaked rice cost US $0.09, a loss of $0.36/day or $10.80/month was incurred at Farm I and between

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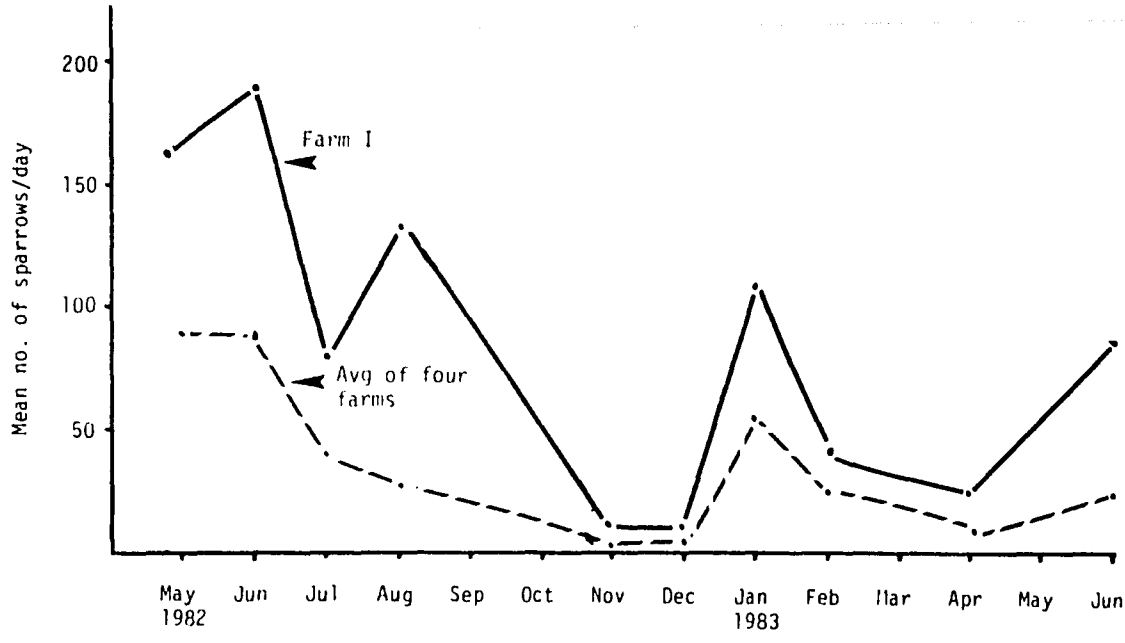


Figure 3. Mean number of European tree sparrows counted per day at Farm I and the average number for the four duck farms near Laguna de Bay, Laguna Province, Philippines.

$0.05 and $0.09/day at the other three farms. Losses to sparrows may be economically important at some farms in the area during certain months. However, the constraints imposed by the duck farmers on the use of any control measures--low costs, no materials that disturb the ducks or require extensive maintenance--present difficulties to resolving the problem.

It is unlikely that the farms and feeding areas could be made less attractive to the sparrows. Excluding sparrows from the duck pens with netting might be effective but economically impractical. Rid-A-Bird perches (without toxicant) did not attract birds. The Last Perch Trap was not visited by any sparrows, despite being placed in several locations, baited, and decoyed with live birds. Hav-A-Hart[R] and bird funnel traps are now being tested. On 22 May and 9 August 1982, two professional bird trappers caught 364 total birds at Farm I using a "korag" or clap trap. Using mist nets, 258 sparrows were caught on five different days between 29 May and 13 August 1982. If trapping sparrows actually reduced feed losses, this would be recommended as it could be used at no cost to the farmer, while providing an income to the trapper.

Evaluating Trimethacarb as a Bird Repellent

The purpose of this work was to begin preliminary evaluations of trimethacarb as a bird repellent. The work in the Philippines was a part of studies conducted in five countries during 1983 to determine the effectiveness of this chemical as a seed dressing and head spray.

In the Philippines in laboratory studies, R50 and LD50 values were obtained on several species of pest birds using standard laboratory techniques. In the field, two trials were conducted at Los Baños between February and April 1983 to evaluate trimethacarb at 3- and 4-kg a.i./ha application rates applied to ripening sorghum. In the first trial, 3 sorghum bands, between 150 and 350 m^2, were sprayed twice (at a 10-day interval) with trimethacarb at 3 kg a.i./ha. Trial bands and a 150-m^2 untreated band were separated by at least 50 m from each other. Experimental bands were part of a 4,174-m^2 mixed variety sorghum field. In the second trial, one 1,739-m^2 plot was sprayed with trimethacarb at 4 kg a.i./ha about 2 weeks after flowering; the other plot, 2,312 m^2, was left untreated. In both trials, bird counts and damage estimates were made before and after spraying. In addition, 200 sorghum heads in each plot were covered with mesh bags to prevent bird damage. Stalks of another 200 exposed heads were marked with planter tags at spraying time and assessed at harvest, April 18-22, for damage.

Residue analyses also were obtained from sorghum heads from fields sprayed either once or twice with trimethacarb at 3 or 4 kg a.i./ha. Sorghum heads were collected at harvest, dried in an air-conditioned room, and within 7-10 days of harvest shipped to DWRC. At DWRC, sorghum seeds were separated and analyzed separately from glume and stalk.

The 3 kg a.i./ha trimethacarb applications provided only limited protection. Reduced numbers of European tree sparrows continued to visit treated sorghum plots. At the trial's conclusion, damage was 2.1 times greater in treated plots and 1.3 times greater in the untreated plot compared to pretreatment levels (Table 26). R50 studies (R50 = 0.13) showed that European tree sparrows, the principal pest, were not as sensitive to trimethacarb as spotted munias (*Lonchura punctulata*) (R50 = 0.05) (Table 27).

In the second trial, sorghum was sprayed at the rate of 4 kg a.i./ha with considerably better results (Table 28). Sorghum yield at harvest was greater in the treated than untreated plot, despite larger and heavier average head size in the untreated plot. Birds also stopped feeding in the treated plot, some apparently moving to the untreated plot (Fig. 4). Actual yield averaged about 500 kg/ha more for the treated than untreated sorghum (Table 28). The effectiveness of the 4-kg a.i./ha application rate was verified in outdoor cage tests with spotted munias.

Table 26. Total daily number of European tree sparrows and % damage to ripening sorghum before and after trimethacarb application[a] at 3 kg a.i./ha, Los Banos, Philippines, 1983.

Bands	Size (m^2)	Total birds/day[b] Pretreatment Feb 22-24	Posttreatment Feb 25-Mar 7	Posttreatment Mar 8-11	% damage Pretreatment Feb 25	Posttreatment Mar 7	Posttreatment Mar 15
Treated							
17-18	150	8	14	6	10	27	29
31-33	225	46	8	1	25	42	43
58	350	28	3	0	12	28	31
Total/Avg	725	27	9	2	16	32	34
Untreated							
9-10 only	150	0	0	6	8	7	11
All other	3,299	71	67	59	-	-	-

[a] Trimethacarb applications were made on Feb 25 and Mar 7.
[b] Total European tree sparrows counted in each band at four 30-min intervals between between 0800-1000 and again at 1500-1700.

Table 27. Comparison of LD50 (mg/kg) and R50 (%) with 95% confidence intervals of trimethacarb for several species of pest birds in the Philippines. Reference is given for values not determined in this study.

Species	$\bar{x}$ wt (g) of test birds	Trimethacarb		Methiocarb[a]
		LD50 (UCL-LCL)	R50 (UCL-LCL)	R50 (UCL-LCL)
Passer montanus	18.5	18.1 (32.7-10.1)	0.13 (0.20-0.09)	
Lonchura punctulata	10.5	19.6 (28.8-13.3)	0.05 (0.06-0.04)	0.06 (0.88-0.04)
Lonchura leucogaster	11.9	10.0 (32.3- 3.1)		0.04 (0.05-0.03)
Lonchura malacca	12.4			0.04 (0.07-0.03)

[a] Source: Garrison and Libay (1982). Philipp. Agric. 65(4):363-366.

Table 28. Comparison of bird damage in a vulnerable sorghum field sprayed twice (Mar 23 and Apr 6) with trimethacarb at 4 kg a.i./ha and fields left untreated, Los Baños, Philippines. Data are based on samples of about 200 heads in each plot.

Plot	% damage		Actual yield	$\bar{x}$ harvest wt (g)		$\bar{x}$ head length
	Mar 24	Apr 14	(kg/ha)	Uncovered	Covered	(cm)
No. 8 - Treated	6	7	1,770	21	26	16
No. 7 - Untreated	2	14	1,280	28	34	17

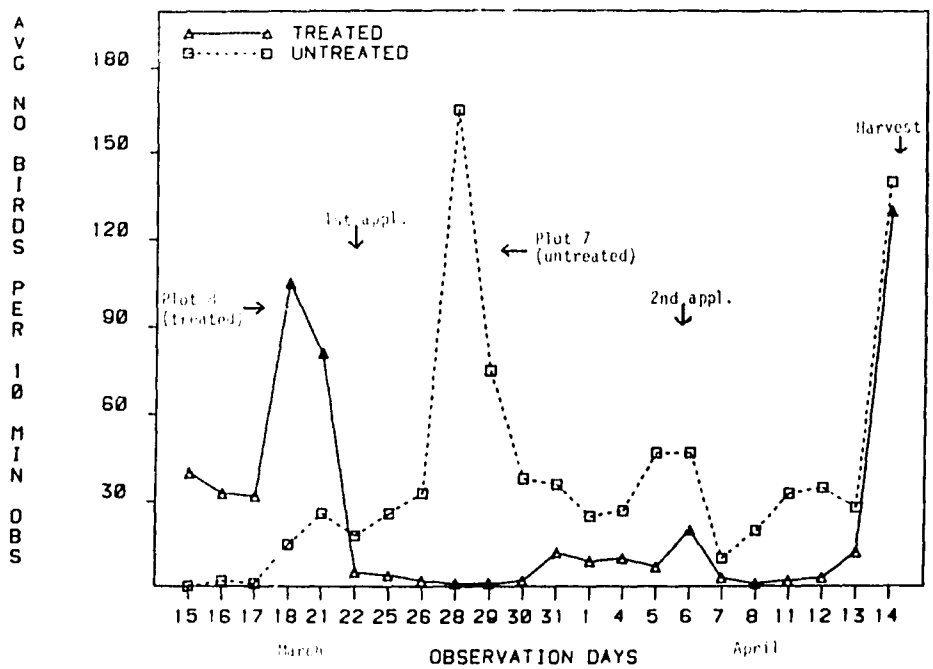


Figure 4. Avg no. birds observed in a trimethacarb-treated and untreated plot in Los Baños, Philippines, based on the maximum number of birds observed each 10-min interval.

Residues on sorghum seed at harvest treated in the Philippines at 3 kg a.i./ha were 0.18 ppm and at 4 kg a.i./ha were either 0.42 or 0.68 ppm depending on the plot (Table 29). Comparable residues were found on seed treated at 4 kg a.i./ha either once or twice. These harvest residue levels were also similar to those found on rice in Haiti.

Table 29. Trimethacarb residues remaining on the seed and glume/stalk of sorghum collected at harvest and about 4 weeks after the application and 2 weeks following second application, Los Baños, Philippines, 1983.

Plot	No. applications	Application rate (kg a.i./ha)	Date		Trimethacarb (ppm)[a]	
			Spray	Collection	Seed	Glume/stalk
5	1	4	Mar 23	Apr 18	0.68	7.40
8	2	4	Mar 23, Apr 6	Apr 21	0.42	9.60
11	1	3	Apr 6	May 5	0.18	0.76
6	Untreated	0	-	May 3	ND[b]	ND
7	Untreated	0	-	Apr 21	ND	ND

[a] Based on the major isomer 3,4,5 trimethacarb. The 2,3,5 isomer was not apparent in samples.
[b] ND = None detected.

Efficacy of Fumigating Rat Burrows in Ricefields

Rat burrow treatments are common throughout tropical rice-growing areas of the world, but very little efficacy data are available. Previous trials using the DWRC 85-g gas cartridge in rice provided little or no reduction in rat activity when used during the flowering and mature stages. It was, therefore, evaluated during different growth stages.

Six 0.25-ha plots, two each in the vegetative, postflowering, and mature crop stages were selected as test fields. These fields were separated by at least 100 m in an irrigated area of the International Rice Research Institute (IRRI). All burrows were marked, plugged, and checked the following morning. One DWRC gas cartridge was inserted in any reopened and newly excavated burrow. Two hours after fumigating, the burrows were excavated to determine rat mortality. Rat activity was monitored 3 consecutive nights before and after treatment using tracking tiles. The number of active burrow openings before and after treatment was also recorded.

Eighty-three active burrows were fumigated: 11 in vegetative stage rice, 46 in postflowering rice, and 26 in mature rice (Table 30). Thirty-two dead adult ($\geq$60 g) rats were found in treated burrows; 40 treated burrows were empty. Most (30) of these dead rats were recovered in postflowering and maturing rice plots where breeding was more prevalent. In addition, 96 suckling, nestling, or subadult

rats (<60 g) were recovered, most (91) of them in plots in the latter two crop stages. The highest percent of burrows occupied was in the maturing (69%) and postflowering (46%) crop stage fields. Rat activity was reduced from an average of 64% before treatment to 40% after treatment; the total number of active burrows in all plots declined from 97 to 52 after treatment. The majority of the adult rats collected were females.

Rat activity and burrowing were reduced, even though only half of the active burrows were occupied. In a control program, much time and money would be spent treating empty holes. However, fumigation treatments during peak breeding periods may reduce rat population growth and damage to rice crops. Burrow fumigation does not seem to offer protection to maturing rice. Sustained baiting initiated in earlier rice crop stages would seem to be the most effective method.

Table 30. Effectiveness of the DWRC 85-g gas cartridge in reducing rat activity in different growth stages of rice, Philippines.

Crop stage	Plot	No. active burrows treated	No. treated burrows		% rat activity index before/after treatment		Total no. burrow openings before/after treatment	
			Empty	Rats[a]	Before	After	Before	After
Vegetative	1	6	3	1	48	44	7	3
	2	5	4	1	40	40	5	4
Postflowering	1	19	14	5	86	41	25	13
	2	27	11	10	62	41	29	11
Maturing	1	14	6	7	89	44	17	14
	2	12	2	8	63	33	14	7
Avg or Total		83	40	32	64	40	97	52

[a] ≥60 g.

Perimeter Baiting of Ricefields to Reduce Rodent Damage

The purpose of this demonstration was to test the effectivenss of baiting in fallow areas adjacent to ricefields that harbor rodents. The advantage of this technique is that bait stations can be placed

to intercept rats entering nearby ricefields. A previous attempt to use perimeter baiting in marshes bordering ricefields near Lake Mainit, Mindanao, successfully reduced damage.

The study was conducted at Occidental Mindoro. During the previous 4 years, a 3-ha, rainfed ricefield in this area at Balibago, Abra de Ilog produced yields averaging only 625 kg/ha. The trial site was slightly elevated from nearby ricefields. It was seeded directly on 21 June by broadcasting IR-42 seed into the flooded paddy. A similar-size plot, 1.5 km away, was used as a reference plot. This plot also had severe rat damage and production had averaged only 667 kg/ha the previous 4 years. Rodent species were identified; rat activity was measured using 20 tracking points; and damage was assessed at harvest using a cut-tiller index. A chronic, anticoagulant rodenticide, mixed with whole or broken rice was placed in bait stations when the land was being prepared for planting. Fifty grams of bait were placed in coconut husks at nine peripheral baiting points, 10-25 m from the ricefield's edge. As the bait was consumed, more bait holders and bait were added.

Prior to baiting, 15 and 62 R. argentiventer were captured in the untreated and treated plot, respectively. No other rodent species was collected. Based on tracking point data, rat activity increased to a maximum 4 months after seeding in the untreated plot, but declined during the same period in the treated plot (Fig. 5). Tracking points were 25 x 25-cm areas from which vegetation was cleared and the ground smoothed, over which a thin layer of mud was applied. Grasses were suspended 0.5 m above this area to protect the mud from rain. This approach was effective in recording rodent tracks.

Bait consumption peaked in June (Fig. 6), then gradually declined until harvest. Damage to 100 randomly selected hills in each of six areas in the treated and untreated plots averaged 0.29 (range 0.0-1.01) cut tillers in the treated plot and 15.74 (range 3.98-24.51) cut tillers in the untreated plot. Harvest was 4,450 kg/ha in the treated plot and 2,000 kg/ha in the untreated plot.

Rodent control can be achieved in the Philippines even in the most susceptible areas, such as cultivated riceland adjacent to uncultivated, fallow habitats. This demonstration indicated that by placing bait stations along the perimeter of fields of broadcast rice, substantial damage reduction is possible.

Using Rodenticides in Tracking Grease to Control Rats in Rice

It has proven difficult to stop rat damage in mature ricefields using techniques of burrow fumigation, capture, glueboards, rodenticide baiting, or early harvesting. An alternative method was attempted by mixing an acute rodenticide in a grease/oil

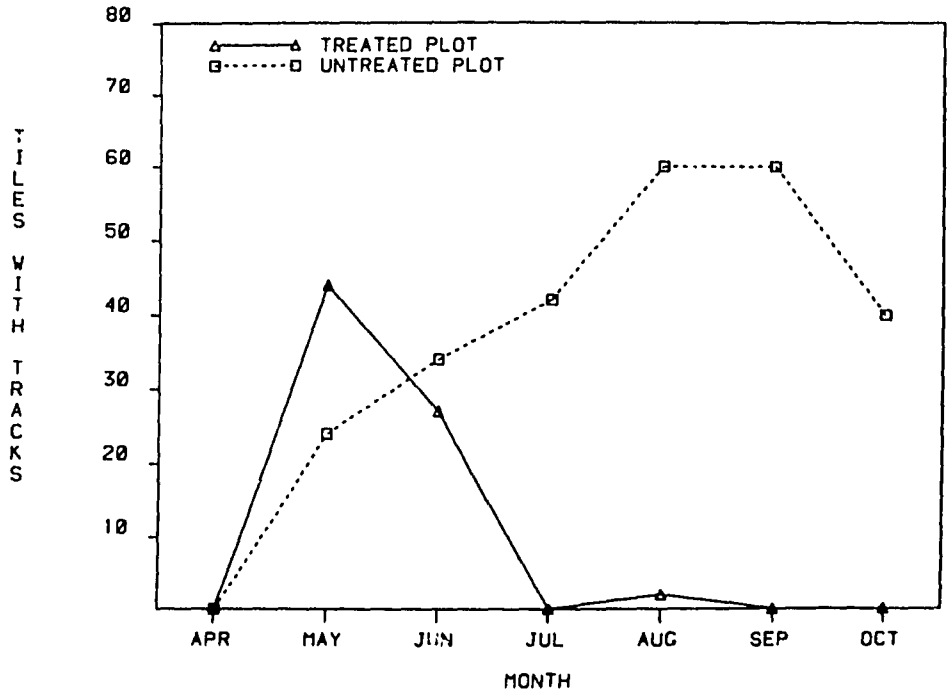


Figure 5. Rat activity in treated and untreated plots based on the number (20) of tracking points marked by rats.

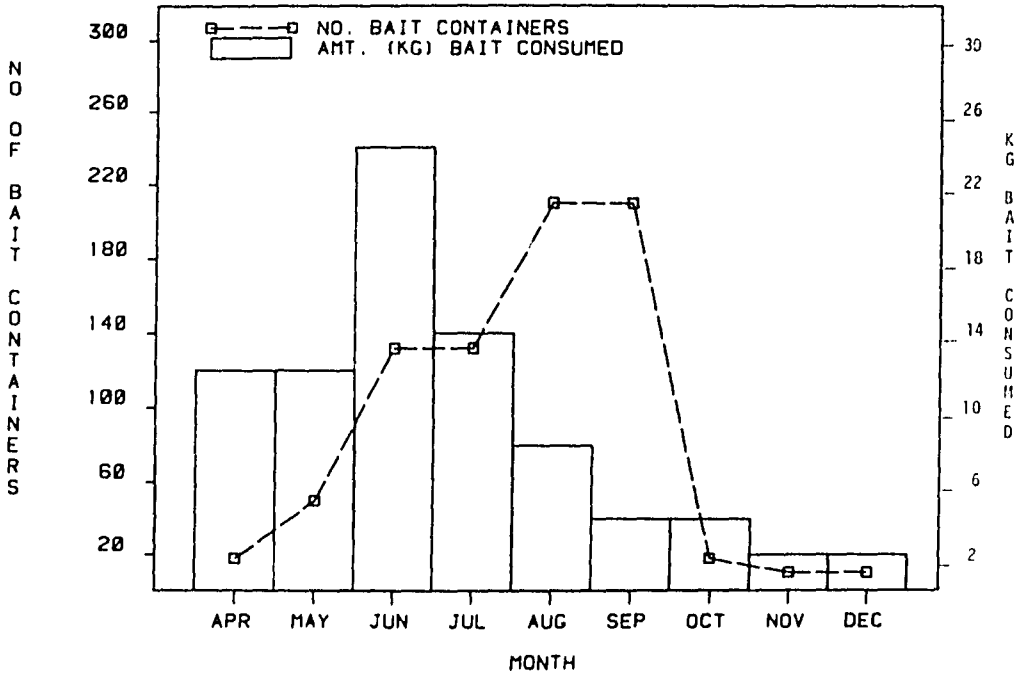


Figure 6. Maximum number of bait containers and amount of bait consumed by rats in a perimeter-baited 3-ha ricefield at Baliiago, Occidental Mindoro.

Coconut husk bait stations, devised by pr[illegible] staff, are now widely used throughout the Philippines to contr[illegible]ents in agriculture.

combination and applying it in small amounts along rat runways in ricefields. Rats contacting this formulation ingested it when grooming. The technique utilizes the same behavioral traits of rats that have made the use of rodenticidal dusts a practical technique in dry, indoor areas. Preliminary studies indicated that 15-20 g of 90% 50/50 grease/oil and 10% zinc phosphide applied to tiles along visible runways in rice paddies might stop damage immediately.

A 0.5-ha area of rice, comprised of 13 plots in different growth stages, was selected at the IRRI. These plots were sequentially transplanted and harvested weekly to produce four crops per year. At any time, all crop stages were present. This entire area was enclosed with electrified or nonelectrified fences. Thirty treated tiles (16 x 7 cm) were placed in five 360-m^2 plots of IR-42 rice variety between 28 January and 10 March. Each plot was treated for 3 consecutive nights when the rice was mature.

Assessment was based on pretreatment and posttreatment rat activity and damage estimates. Rat activity was determined from tracking tiles in the plots for at least 3 nights before treatment and continuing until 9 days after treatment or until harvest. Rat damage was estimated by counting the number of cut and uncut tillers in 50 randomly selected hills per plot before and 1 week after treatment.

In each of the treated plots, rat damage did not increase appreciably and rat activity declined dramatically (Table 31). Although treated Plot 1 had damage of about 20% and rat activity of 83%, each successively treated plot had less rat damage before treatment. This reflected an overall reduction in the rodent population within the study area. The number of above-ground rat nests and burrow openings per plot also declined. This reduction occurred even when adjacent ricefields were being harvested and rats were attempting to enter the study plots. More than 30 dead rats were found one morning outside the study area along the electrified portion of the fence.

These preliminary results suggest that mixing an acute rodenticide in tracking grease can stop rat damage in mature rice, particularly in situations characterized by small, nonsynchronous maturing plots, or when recommended sustained baiting procedures have not been followed. If subsequent field trials are as effective, the method could be developed to offer a rat control method in mature rice.

Table 31. Percent rat damage before and 1 week after treatment and % rat activity during 3 days before and 3 days after using acute rodenticide in mature rice.

Plot no.	Date of transplanting (1982)	Date of treatment (1983)	% rat damage		% rat activity		Harvest date (1983)
			Before treatment	After treatment	Before treatment	After treatment	
1	12 Nov	17 Jan	20	24	83	0	7 Feb
3	26 Nov	4 Feb	11	11	15	0	21 Feb
5	3 Dec	9 Feb	13	10	34	0	28 Feb
7	17 Dec	15 Feb	5	2	28	0	14 Mar
	17 Dec[a]	8 Mar	2	2	28	0	14 Mar
9	31 Dec	8 Mar	2	2	22	0	28 Mar
Avg			10	10	36	0	

[a] Treated twice; results not used for averages.

Cooperation With National and International Organizations

Project personnel cooperated with the IRRI in: (1) establishing a pest bird monitoring program in rice to characterize and define bird damage problems on experimental farm plots; (2) providing technical advise on rodent control in experimental ricefields; (3) writing a vertebrate pest management section for a manual on integrated pest management in rice; (4) conducting research on bird damage to sorghum and testing chemical repellents for efficacy; and (5) advising a Burmese researcher stationed at IRRI for a 1-year rodent control training program.

Several meetings were held with the German technical assistance team assisting the crop protection programs of the Bureau of Plant Industry. These sessions were organized to exchange information and discuss coordination of assistance to the Regional Crop Protection Centers established in 1982.

Technical advice was provided to the Bird/Aircraft Strike Hazard (BASH) team, Tyndal Air Force Base and Clark Air Force Base. Discussions and on-site investigations as to the best approaches to reduce the probability of a bird/aircraft encounter at Clark Air Force Base, Angeles, Philippines were conducted.

Substantial staff assistance was provided to Creative Associates, Inc., a U.S. contractor hired by USAID to develop materials and methods for rodent control extension in coconut technology. The extensive experience of DWRC's Philippine counterparts at NCPC in developing methods and materials for rodent control in coconut on small farms, and field testing revised extension materials helped develop a useful training package which was made available to all USAID Missions in countries where coconut is an important agricultural crop.

Personnel and Training

The popular, 10-month diploma course for crop protection specialists was continued at UPLB. This course has graduated 59 students, including three from other Southeast Asian countries, since it began in 1980. Four other agricultural disciplines have also been offered in the same 10-month diploma format to about 100 other students. This concept, devised by NCPC, has fulfilled a need for practical instruction beyond the 4-year curriculum for agricultural workers.

A variety of other informal and formal training also took place through the project. A Burmese agronomist completed a 1-year study tour at IRRI, working on rodent problems in rice. One Filipino graduate student completed a nondegree vertebrate pest program at Michigan State and returned to the Philippines to work in crop protection. Four other Filipinos pursuing doctoral degrees in

vertebrate pest management presently are enrolled in the U.S. at Bowling Green State University and North Carolina State University.

A training package for rodent control in coconut groves was developed, field-tested, and made available to national extension officers. A 3-year training program was scheduled to begin in 1984. A 1-week training course was offered to NCPC staff to improve office procedures and administrative support techniques.

Assistance was provided to Ms. Paciencia Milan, a Bowling Green State University doctoral student on leave from Visayas State College of Agriculture. Ms. Milan was studying rodents in coconut in Leyte Province. Project personnel assisted the Philippine Council for Agriculture and Resources Research and Development by contributing to a series "Philippine Recommends for Rodent Control" to be released 1984. A rodent biology textbook being produced by NCPC is also scheduled for release in 1984 by the University of the Philippines at Los Baños.

During 1983, DWRC staff traveled in Asia, the Caribbean, Latin America, Africa, and Europe in conjunction with ongoing field research activities and at the request of foreign governments through USAID Missions or USAID Washington, to participate in international meetings, assess vertebrate pest problems, or to review, evaluate, and coordinate present and future research programs. TDY activities from DWRC have become an increasingly important part of the project and DWRC will continue to respond to such requests through USAID. Many types of short-term evaluations and cooperative studies with host-country scientists may be carried out expeditiously in this manner. This travel involved 203 man-days in the following countries:

Bangladesh	Haiti	Kenya	United Kingdom
Indonesia	Peru	Niger	
Pakistan		Senegal	
Philippines		Tanzania	

Travel dates, persons involved, countries visited, and the purpose of each trip are outlined briefly in Table 32. Detailed information is contained in individual trip reports on file at the Denver Wildlife Research Center, Section of International Programs.

An important function of the Section of International Programs is to provide assistance to many countries and international organizations. During 1983, 274 requests from 64 countries were received and answered (Table 33).

AFRICA

Fluorescent Particle Markers

DWRC continued to supply various FAO Eastern Africa Quelea Projects with fluorescent marking materials for cooperative studies of bird movements. Presently, Kenya, Tanzania, Somalia, and Ethiopia have markers. It is important to coordinate the use of these materials for interpretable results. During February 1983, 300,000 quelea in a nesting colony in Tsavo National Park, Kenya, were sprayed with a fluorescent marker formulation. By early March, most birds had left the area. The Tanzania National Bird Control Unit did not find any marked birds in a sample of 1,000 birds in newly established nesting colonies in Tanzania. Another spray is planned at Lake Natron, Tanzania, to determine if birds from that area move into wheat-growing areas around Narok, Nanuyki, and Nakuru, in Kenya. Positive results would further demonstrate the usefulness of this marking technique to learn more about quelea movement patterns and develop crop protection strategies.

Table 32. International travel for technical assistance projects by USAID/USFWS-DWRC personnel during 1983.

Date	Name	Location	Purpose of Visit
15 Feb-13 Mar	R. L. Bruggers	Philippines, Kenya, Tanzania, Senegal	Philippines: Organize field trials and and set up laboratory tests for trimethacarb on bird pest species. East Africa: Discuss cooperative work with FAO Quelea Project personnel. East and West Africa: Discuss with authors their contribution to the quelea book.
15 Mar-2 Apr	D. J. Scott	Philippines	Provide office management guidance, discuss administrative procedures with project leader, and gain better understanding of interactions among DWRC and USAID-funded overseas project, host government, and USAID.
20 Mar-2 Apr	M. W. Fall	Haiti	Assist project leader in fieldwork, review data, and assist planning future project activities.
23 Mar-29 Apr	J. W. De Grazio	Pakistan, Bangladesh, Philippines	Pakistan: Develop two preliminary proposals on vertebrate pest problems and solutions for possible implementation into the USAID/Pakistan-sponsored Agriculture Production, Distribution, and Storage (APDS) Project. Bangladesh and Philippines: Review research and administrative activities at USAID/DWRC projects.

Date	Name	Location	Purpose of Visit
26 Mar-15 Apr	J. E. Brooks	Pakistan	Assist in developing two preliminary proposals on vertebrate pest problems and solutions for possible implementation into the USAID/Pakistan-sponsored Agriculture Production, Distribution, and Storage (APDS) Project.
20 Apr-1 May	R. L. Bruggers	Haiti	Initiate trials to protect newly sown seeds from pest birds. Conduct surveys for bird and rat damage.
19 May-1 Jun	R. L. Bruggers	England, Kenya	England: Discuss rodent bibliography and bird pest problems with Tolworth and Worplesdon Laboratory. Discuss bird and rodent repellents with Sphere Laboratories. Represent USAID/DWRC in FAO Quelea Project 4th Annual Technical Meeting and make tentative plans for cooperative research for 1984.
5-9 Sep	L. A. Fiedler	Indonesia	Observe crop protection planning activities.
7 Sep-7 Oct	P. J. Savarie	Bangladesh, Philippines	Assist with laboratory evaluation of new rodenticides; evaluate status of rodenticides used; and plan future toxicological tests (Bangladesh). Assist in developing collaborative studies with NCPC (Philippines).

Date	Name	Location	Purpose of Visit
17-25 Sep	J. W. De Grazio, M. W. Fall	Niger	Present four papers at USAID/OAU Inter-african Phytosanitary Council Training Conference "Vertebrate Pests of West African Crops."
9-15 Oct	D. J. Elias	Peru	Attend 9th Latin American Zoology Congress and chair symposium "Economic Zoology and Vertebrates as Pests of Agriculture."

Table 33. Requests to DWRC for assistance during 1983. This table does not include requests to DWRC biologists stationed at field stations in Haiti, the Philippines, and Bangladesh.

Type of request or activity	Months												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Information on International Programs	2	2	6	2	0	3	0	1	1	2	1	1	21
Literature or information on research and crop protection methods	6	14	12	22	7	18	13	4	3	19	9	7	134
Graduate school inquiries	1	4	2	0	0	1	4	0	0	0	3	2	17
Workshops/symposia/conferences	11	5	1	1	0	4	0	1	3	1	0	0	31
Materials/photographs	2	2	3	2	0	1	2	0	0	0	1	0	13
TDY's/project requests	0	1	3	2	2	5	2	2	1	0	2	4	24
Hiring possibilities	0	1	2	0	0	2	0	0	0	1	0	0	6
Visits or visitors to DWRC	0	0	1	0	4	5	4	2	0	0	8	0	24
Funding	0	0	0	0	0	0	1	0	1	1	1	0	4
TOTAL	22	33	30	29	13	39	26	10	9	24	25	14	274

Originating countries:

Jan Egypt, Switzerland, Thailand, Haiti, Tanzania, Argentina, Canada, Mexico, Uruguay, Venezuela, Colombia, USA, Peru, Brazil, Chile.

Feb Argentina, USA, Panama, Ethiopia, Colombia, Somalia, Nicaragua, Denmark, Venezuela, Dominican Republic, India, Costa Rica, Pakistan, Mexico, Canada.

Mar Dominican Republic, Haiti, Panama, Indonesia, Ethiopia, Sudan, Guatemala, Peru, Uruguay, Zaire, USA, Mexico, Somalia, Kenya, Italy, Papua New Guinea, Central African Republic, Morocco, New Zealand, Canada.

Apr Uruguay, Argentina, New Zealand, Guyana, USA, Guatemala, Pakistan, Bangladesh, Nigeria, Indonesia, Costa Rica, Panama, Colombia, Italy, Bolivia, Peru, Canada, Malaysia.

May Philippines, Tanzania, USA, Cape Verde, Mali, Bangladesh, Italy, Kenya.

Jun Zambia, Kenya, Cape Verde, Cameroon, Sudan, Ethiopia, Pakistan, Costa Rica, Italy, England, Tanzania, Bangladesh, Thailand, Uganda, India, Egypt, Guyana, USA, Peru, New Zealand.

Jul USA, Australia, India, Honduras, Nicaragua, Egypt, Germany, Sierra Leone, Mali, Tanzania, Uruguay, Ethiopia, Sudan, England.

Aug Puerto Rico, USA, Tanzania, Ethiopia, India, Botswana, Latin America, Kenya, Sudan.

Sep USA, Tanzania, India, Pakistan, Yemen, Costa Rica, Uruguay, Niger.

Oct Thailand, Canada, India, South Africa, USA, Italy, Ecuador, Guinea Bissau, Niger, Fiji, England, Mali, Morocco, Liberia, Australia, Chile, Venezuela, Peru, Argentina, Uruguay.

Nov USA, Guinea Bissau, Liberia, Italy, Tanzania, Zimbabwe, Costa Rica, Switzerland, Israel, Brazil.

Dec Upper Volta, Uruguay, USA, Ethiopia, Qatar, Israel, Costa Rica, El Salvador, Tanzania, Indonesia, Malawi, Mexico, Peru, Colombia.

Quelea Book

The book "The Biology and Management of the Red-billed Quelea, which is bringing together much of the research, management, and training aspects of quelea work conducted during the past 20 years, is progressing well. Authors and chapter topics have been determined, and many authors were personally contacted during DWRC's outreach travel. DWRC and FAO personnel are editing the book. Chapters will be reviewed, revised, and prepared for Oxford University Press by the end of 1984.

VERTEBRATE PEST PROBLEM DEFINITION

Pakistan

In Pakistan, DWRC biologists devloped two preliminary proposals on vertebrate pest problems and solutions for possible implementation into the USAID/Pakistan-sponsored Agriculture Production, Distribution, and Storage (APDS) Project. These proposals, "Vertebrate Pest Management for Edible Oilseed and Cereal Crops in Pakistan" and "Postharvest Food Losses Caused by Vertebrate Pests," were based on information compiled during several missions in 1982. Discussions with numerous officials of USAID, USDA, and Government of Pakistan organizations, including Pakistan Agricultural Research Council, National Agriculture Research Center, Vertebrate Pest Control Laboratory, and the Ghee Corporation of Pakistan established the critical need for such work in Pakistan.

TRAINING

Because of growing recognition of the importance of vertebrate pests to food production and storage in most countries of the world, there is an increasing need for specialists to define, research, and manage these problem species. Recognizing the need for graduate training in the newly emerging field of Vertebrate Pest Management (VPM), the Department of Fishery and Wildlife Biology, Colorado State University (CSU), has developed a cooperative arrangement with the U.S. Fish and Wildlife Service's Denver Wildlife Research Center for individuals seeking advanced education in Vertebrate Pest Management and fields related to the control of animal damage. A special effort has been made to address the individual needs of international participants in managing vertebrate pest problems in their home countries. This effort supplements programs presently existing at other universities.

The academic program consists of courses such as

Principles of Wildlife Management	Mammalogy
Wildlife Management Techniques	Ornithology
Vertebrate Pest Management	Animal Behavior
Wildlife Ecology	Wildlife Population Dynamics
Statistics	Wildlife Nutrition
Wildlife Biology Seminar	Public Relations in Natural Resources
Independent Study in Vertebrate Pest Management	Economics of Natural Resources

The graduate research may be conducted at Colorado State University, at the Denver Wildlife Research Center, or at various cooperating field stations in the United States or other countries. In the latter cases, a research scientist at the field station, who also is an appointed CSU affiliate faculty, will be designated to supervise the student's progress. Prospective students engaged in rodent or bird control operations or related research in VPM in tropical countries are urged to consider this offering for specialized graduate education. Programs lead to the master of science or doctor of philosophy degrees.

During the 3 years this program has existed, 23 students, including individuals from Malawi, Sudan, Nigeria, Venezuela, Bangladesh, and Ethiopia have enrolled. Several of these students have completed or are in the process of completing advanced degrees in a variety of topics relating to bird hazards to aircraft, bird pests in Bangladesh, vertebrate pests of Venezuela, and wildlife management in Sudan.

For additional information including the General Catalog, International Student Information Brochure, and detailed application procedures, contact:

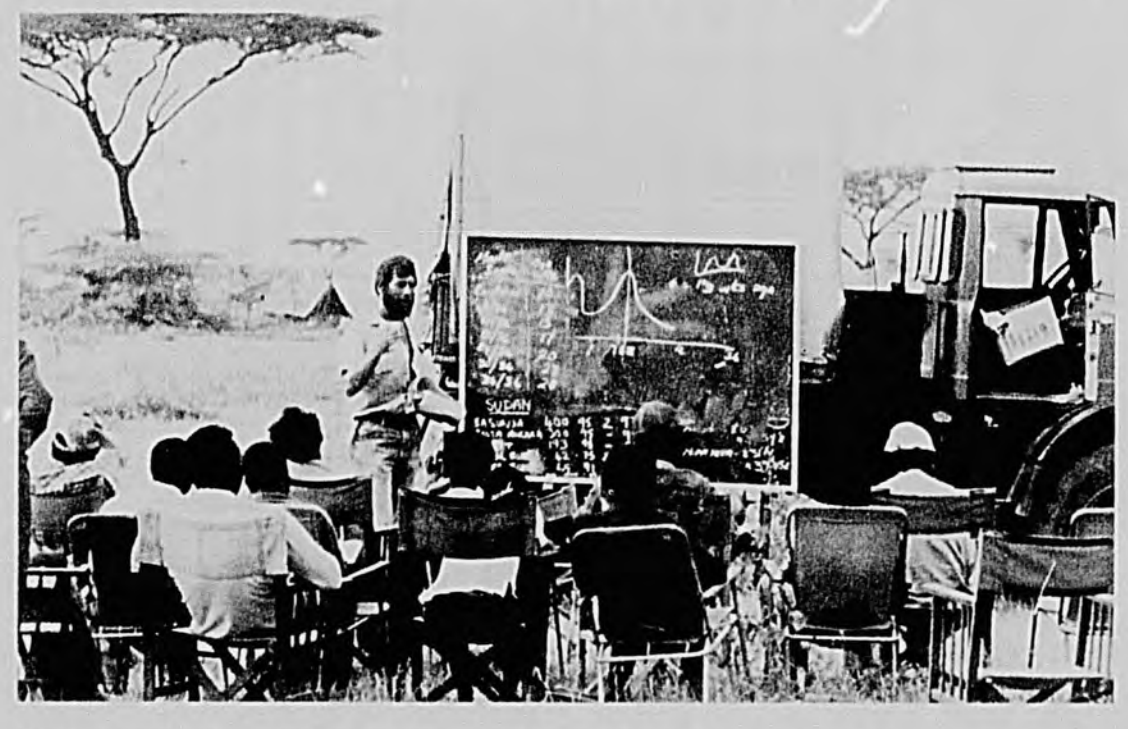
Dr. Julius G. Nagy, Professor of Wildlife Biology
Department of Fishery and Wildlife Biology
College of Forestry and Natural Resources
Colorado State University
Fort Collins, Colorado 80523 USA
Telephone: (303) 491-5901

DWRC also continued to assist graduate student researchers in Vertebrate Pest Management at Bowling Green State University, at the University of California at Davis, at North Carolina State University, and at the University of the Philippines at Los Baños. Some candidates for advanced degrees visited DWRC during the year or conducted their research under the guidance of DWRC biologists.

In addition, DWRC helped organize and participated in a USAID Regional Food Crop Protection Project and OAU Interafrican

Phytosanitary Council-sponsored training conference, entitled "Vertebrate Pests of West African Crops" in Niamey, Niger; 19-23 September 1983. The goal of the conference was to bring the latest research results to individuals of each country in the best position to implement pest management. OAU Phytosanitary Council established work groups of participants to synthesize the speeches of the experts and make practical recommendations on the most effective and economical means of bird and rodent control. Participants included representatives from Sahelian countries including crop protection services of Mauritania, Senegal, Gambia, Cape Verde, Guinea-Bissau, Mali, Upper Volta, Niger, Cameroon, and Chad. Speakers were invited to lecture or conduct workshops on the subjects of bird and rodent pests of the Sahel, damage assessment techniques, control methods and strategies at the national and regional level, lethal and nonlethal crop protection, rodent control for small-farm agriculture and in storage, determining movement patterns, environmental concerns, and training and research needs. The proceedings from this workshop were to be published in French and English.

In the countries of eastern Africa, the local and migratory movement patterns of red-billed quelea are being worked out by studying morphologic features, such as feather molt, cranium pneumatization, mask patterns, bill color, and gonad development.



DWRC regularly conducts or assists other organizations in training workshops in vertebrate pest management.

Rodenticide-treated Nest Material to Control *Bandicota bengalensis*

The lesser bandicoot rat (*Bandicota bengalensis*) inhabits the rice- and wheat-growing regions of Bangladesh and causes extensive damage to these crops. Although several rat population reduction methods (rodenticide baiting, burrow fumigation, trapping) are available, an alternate means of controlling this species could involve placing poison-treated nest material near the burrows for pickup and caching by rats. This rodenticide delivery method could offer the advantage of acceptance by rats even during the dry season when bait acceptance is poor due to grain hoarding in burrows or bait shyness.

Two 1.5 x 3-m sheet metal enclosures were used to house pairs of *B. bengalensis* in a 13-day preference test with four types of nest materials (kraft paper, straw, burlap, and cotton). Results indicated that kraft paper strips were consistently preferred (98.0 and 96.1% preference); cotton was the least preferred material (9.6 and 32.6% preference).

Next, the acceptance of 1.00% zinc phosphide in corn oil and 0.02% brodifacoum treatments on the kraft paper nest materials will be compared. If high mortality is observed for either or both rodenticides, other concentrations and binding agents will be evaluated.

Blood Indices of Lithium Chloride and Correlated Taste Aversion in Wild Rats

Between 1979 and 1982, studies were continued to develop taste aversion as a field technique for protecting crops and stored foods from rodent damage. Taste aversion refers to reductions in the rodent's consumption of novel-tasting substances following ingestion of the substance paired with an illness-inducing drug. Previous work showed that Philippine rice rats (*Rattus rattus mindanensis*) significantly reduced intake of saccharin-flavored rice for 2-4 weeks after a single exposure to saccharin-flavored, lithium chloride (LiCl)-treated rice bait.

Relationships between blood levels of LiCl and degree of acquired aversion need to be defined to further develop field baiting procedures with taste-aversion agents. To examine the pattern of lithium uptake in the blood of *R. r. mindanensis*, male rats received 350 mg/kg doses of LiCl in water by gastric intubation. Individual rats were anesthetized at 0.08, 0.25, 0.5, 1, 4, 8, 24, 72, 96, and 120 h after dosing, and blood samples were collected via heart puncture.

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Following dosing, LiCl serum values increased rapidly to 22 ppm by 0.5 h, decreased to 15 ppm at 1 h, increased again to 25 ppm after 4 h, then gradually declined to control levels (1-2 ppm) by 96 h. These data confirm that a 350-mg/kg dose of LiCl causes rapid, prolonged elevations in serum lithium in rats. Thus, serum lithium provides a useful index of LiCl ingestion that should facilitate development of field baiting procedures.

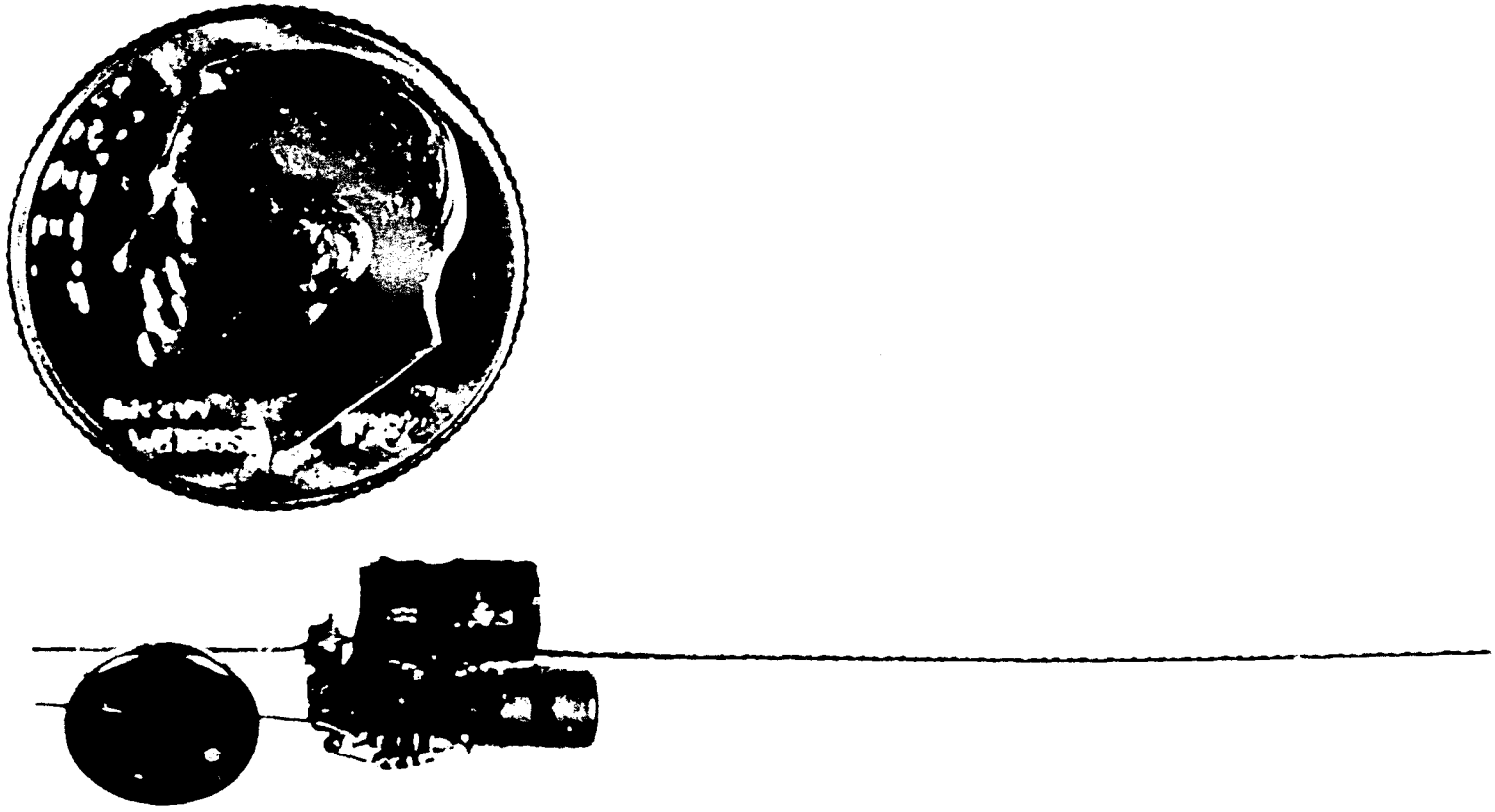
Miniature Radio Transmitter Developed

A total of about 150 specialized transmitters were produced by bioelectronics personnel in 1983. Every transmitter produced satisfied a unique design requirement involving size, weight, or performance; such transmitters are not commercially available. In addition, several new components were incorporated to improve the electrical characteristics of former designs. One area of research where substantial progress was made was in the miniaturization of wildlife transmitters. Several 1.1-g radio transmitters have been built for studies of golden sparrows (*Passer luteus*) and red-billed quelea (*Quelea quelea*) in Africa. These transmitters did not operate for the calculated battery life of 20 days, because shelf life of the batteries had been exceeded.

Determining Trimethacarb Residues in Sorghum and Rice

Sorghum from the Philippines and rice from Haiti were analyzed for residues of trimethacarb as part of a study to assess bird repellents. The analytical method used was a modification of a method developed by Union Carbide Agricultural Products, Inc. The Union Carbide method involved capillary gas chromatography of trimethacarb directly without derivatization and quantitative measurement with a thermionic nitrogen-phosphorous detector. The modifications included changes in the cleanup procedure to facilitate analysis of smaller samples and the use of a short (40 cm x 2 mm i.d.), packed gas chromatographic column instead of a capillary column to minimize degradation of the thermally labile compound. Recoveries of more than 95% were obtained from samples fortified with 0.1- to 5-ppm trimethacarb.

Trimethacarb degraded rapidly on rice samples from Haiti. Following 4- and 8-kg a.i./ha application rates, average residues of 9.4 ppm and 465 ppm at the milk stage, respectively, declined to 0.1 ppm on the seed (both application levels) at harvest. Discrepancy between residue levels immediately after application may have been caused by contamination or poor sampling procedures. However, the degradation pattern for both levels is initially rapid and like the pattern found for the 2-kg a.i./ha application of methiocarb. Half-life was 5.2 days for the 4-kg a.i./ha application and 4.2 days for the 8-kg a.i./ha application. Residues exceeding the R50 of most bird pests tested were on both seeds/glume samples and the seeds only at 21



Exclusive of the battery and encapsulation material, this small radio transmitter for birds weighs 330 mg. An operational unit having a predicted life of 25 days weighs 1.1 g.

days after spraying. The amount of chemical on the seed at harvest was far less than the amount shown to inhibit germination; therefore, sprayed seeds could be used as seed stock without reduced germination.

Developing Sorghums That are Less Susceptible to Bird Damage

Sorghum varieties that have been categorized as Group II sorghums have genetic tannin characteristics that reduce their susceptibility to bird damage during the immature stages, but yet mature with high nutritional qualities. Through collaborative work between DWRC and the University of Arkansas, five varieties were identified that seem to have the desired Group II characteristics. Seeds from these five Group II sorghums were sent to Haiti for planting to determine if immature-stage Group II sorghums are avoided by birds. A test design was developed to compare all five varieties for bird susceptibility in the same field.

Evaluating Experimental Rodenticide M&B 36,892A in Wild Norway Rats (*Rattus norvegicus*)

An acute oral, single-dose chemical producing delayed mortality in rodents was evaluated. A preliminary acute oral LD50 (with 95% CL) for M&B 36,892A using two male and two female wild Norway rats per dose level resulted in values of 100 mg/kg (66.8-150.4) and 44.5 mg/kg (29.7-66.8), respectively. Using five animals per dose level, the LD50 in males was calculated to be 107.8 mg/kg (70.8-158.8) and in females 20.8 mg/kg (19.7-49.7) (Table 34).

Table 34. Acute oral toxicity of M&B 36,892A to fasted wild Norway rats.

Dose (mg/kg)	Mortality		
	Male	Female	Combined
225	5/5	not tested	5/5
150	4/5	5/5	9/10
100	3/5	5/5	8/10
66.7	1/5	5/5	6/10
44.4	0/5	4/5	4/10
29.6	0/5	3/5	3/10
19.7	not tested	1/5	1/5
13.1	not tested	0/5	0/5

The greater susceptibility of female Norway rats also was observed in a two-choice feeding test using untreated EPA challenge diet (65% oatmeal, 25% cracked corn, 5% sugar, 5% corn oil) and EPA diet containing 0.18% M&B 36,892A (Table 35). The test was conducted for 3 days and cup positions were reversed daily to overcome position preference by rats. The two male rats that died consumed 63.3 and 136.6 mg/kg and the eight survivors consumed an average of 55.3 mg/kg (range = 11.3-112.3). The nine female rats that died consumed an average of 134.1 mg/kg (range = 56.4-253.3). The single female survivor consumed 56.6 mg/kg.

Table 35. Comparison of free-choice feeding on 0.18% M&B 36,892A and untreated feed for 3 days in wild Norway rats.

			Bait consumed				
			Treated		Untreated		Total
Sex	N	Mortality	(g)	(%)	(g)	(%)	(g)
M	10	2/10	130.3	43.1	171.9	56.9	302.2
F	10	9/10	170.9	48.3	182.8	51.7	353.7
M	5	0/5	-	-	274.9		274.9
F	5	0/5	-	-	208.7		208.7

A wide variety of structures are used in developing countries to store grain and protect it from vertebrate pests, particularly rodents.

Managing Postharvest Vertebrate Pest Problems in Developing Countries

A food protection project was established in 1982 at DWRC to coordinate postharvest food loss research activities. This is a new area of research in the USAID program; already a large reference collection has been established. Over 400 reprints and 300 microfiche cards were received, most of which have been cataloged and filed. More references from laboratories or agencies within developing countries will be added, and the system will be stored for computer access.

Field studies were underway or planned in the Philippines, Haiti, and Bangladesh, and arrangements were made to collaborate with Kansas State University in a program in El Salvador.

Stored Commodities Survey in Bangladesh

Preliminary results from interviews with 25 farmers in one district indicated that the bamboo dhol (basket) was the most commonly used storage container (Table 36). Farmers also used motka, a large earthenware vessel with a rather narrow neck, tin cans, and gunny sacks. Bamboo dhols, clothes, bedding, books, jute items, building structures, and papers also were damaged by rodents.

Table 36. Types of grain storage containers used in Bangladesh. Based on interviews with 25 farmers.

Type storage container	No. farmers using each type	$\bar{x}$ storage capacity (kg)
Bamboo dhol	25	36,630
Motka	23	4,810
Tin can	7	666
Gunny sack	7	1,480

Reported losses to stored foods were about 2.8% ($512) of total commodities valued at $17,960. Losses of household items added another $253 for the 25 households. The average loss per household was about $29.50 for the 6-month period before the interview.

Postharvest Stored Food Losses on Farms and in Villages in Bangladesh

A pilot study of the abundance of small mammals in farm structures was initiated in Bogra Village, September 1982. Animal activity was assessed before and after trapping, using inked tracking tiles placed in and around houses. Small mammals were snap-trapped and removed for 3 nights from 24 different farm structures each month for 1 year. Captured animals were identified, sexed, weighed, measured, and autopsied. Reproductive condition was recorded and the stomach contents were removed and preserved.

A total of 606 animals was captured: 2 *B. indica* (0.3%), 46 *B. bengalensis* (7.6%), 31 *Rattus rattus* (5.1%), 322 *Mus musculus* (53.1%), and 205 *Suncus murinus* (33.8%) (Table 37). The number of animals captured varied seasonally and peaked in December/January and again in July. These peaks correspond with harvest periods of the several rice crops when rodents moved into the houses and farm structures. Population estimates, based on the change in proportion of activity relative to the number of animals removed, varied from 170 animals at all farms in December 1982 to 35 and 34 in March and August 1983, respectively.

Table 37. Rodent activity, trap success, and estimated original animal population in 24 farm structures at Bogra Village, Bangladesh.

Date	Tracked tiles (%)		No. animals captured (all structures)	Estimated original population (all structures)
	Pretrapping	Posttrapping		
Oct 82	41.7	14.9	74	115
Nov	50.0	23.1	74	138
Dec	50.0	27.1	78	170
Jan 83	33.3	6.2	80	98
Feb	27.8	12.5	52	94
Mar	27.8	11.1	21	35
Apr	36.1	18.1	43	86
May	34.7	26.4	34	142
Jun	25.0	15.3	46	118
Jul	30.6	19.4	57	155
Aug	22.2	8.3	21	34
Sep	19.4	13.9	27	95
Total/Avg	33.2	16.6	607	1,280

Numerous baskets, pans, and other vessels are used to store grain in housing clusters in Bangladesh.

Indian house crows tear grain sacks and eat rice or wheat on its way to the market or storage centers in Bangladesh.

Mynas are a common sight in Bangladesh eating swathed rice.

The estimated average density of rodents (excluding shrews which are not known to significantly contribute to losses of stored foods) in the 24 farm structures varied between 131 animals in December and 20, 24, and 24 in March, April, and August, respectively. However, an average of only three rodents was trapped per monthly trapping period in each structure. Thus, population estimates were undoubtedly low because bandicoot rats, although living in houses, were not captured, and because householders set traps on the floor and not near food storage baskets where most rodent feeding activity was concentrated. Subsequent studies need to be conducted in and around farm and village structures in deepwater rice-growing areas and in houses where tube well irrigation is used, since the variety of stored commodities is greater in these areas.

Rodent Damage to Stored Grains in a Village in the Philippines

Rodents responsible for preharvest crop damage also inhabit housing and storage structures near ricefields. When ricefields are harvested, these rodents often move into or around village dwellings, where farmers store their share of the crop. The purpose of this study was to determine potential damage caused by rats and mice to stored grains in households, small stores, and other buildings in a typical Philippine village.

At Tubuan, Pila, Laguna Province, 60 structures were randomly selected in August and another 48 in September to survey the amounts and kinds of stored grain, storage methods and their use, and the incidence of rodent damage. Rodents also were trapped and identified in 45 of these structures immediately after the survey.

Farmers stored more grain in August than in September, which reflected their use of grain stored from the previous harvest. Greater rodent damage to stored grain and greater trap success also occurred in August (Table 38). The decreased capture of all three species of *Rattus* from August to September probably resulted from increased movements into wet season ricefields that were beginning to mature at that time. However, captures of *R. norvegicus* also declined. This species is only occasionally trapped in ricefields near villages. The aparent increase in the activity of *M. musculus* and *S. murinus* might be expected to occur if the reduction in rat numbers was a real effect.

These initial results indicate that typical rural dwellings are receiving damage to stored grain from as many as four rodent species. Damage in large warehouses has been found to be insignificant at the national level, but damage to farm storage could be extensive. Trapping and examining structures should be continued to determine seasonal trends in rodent abundance and damage.

Table 38. A summary of stored grain, rodent damage, and rodent species present in housing structures in a Philippine village during 1983.[a]

	August	September
Stored grain/structure (kg)		
Rice (unhulled)	140	74
Rice (hulled)	20	16
Corn (grits)	0.4	2
Rodent damage		
No. sites with grain	20	13
No. sites with damage	15	7
Incidence of damage (%)	75	54
No. small mammals trapped		
Rattus rattus	31	6
Rattus exulans	20	7
Rattus norvegicus	20	2
Mus musculus	23	28
Suncus murinus	23	44

[a] Index per 1,000 trap nights but based on 741 and 680 trap nights during August and September, respectively.

Granary Losses of Stored Grain to Sparrows and Pigeons

Adult sparrows (*Passer domesticus*) and pigeons (*Columba livia*) were maintained in a simulated storage facility to evaluate methods of assessing postharvest food losses due to consumption and contamination. Bird Tanglefoot[R] also was evaluated as a means of reducing bird damage to stored cereal grains.

Sparrows and pigeons were offered a choice among several foods to determine food preference; sparrows preferred millet, and pigeons preferred sorghum. However, when the birds were offered only one food item, each was eaten in comparable amounts.

To assess damage and contamination, 10 pigeons and 10 sparrows were put in separate pens simulating grain storage facilities with 45 kg sorghum and 7 kg millet, respectively, for 3 weeks. Each pen was divided and grain was "stored" in the back section and Purina Game Bird Chow placed in the front. The grain compartment of each pen either had wooden perches, perches smeared with Tanglefoot, or no perches. These three treatments were replicated twice for each species. Birds consumed the most food in pens with untreated

perches and the least food in pens with Tanglefoot-treated perches. In pens with untreated perches, a correlation existed between the amount of grain contaminated and consumed. Both visual and volumetric analyses indicated that contamination was confined mainly to the surface layer, about 2.5 cm deep. Pigeons in pens with Tanglefoot-treated perches did not visit the storage area but fed on alternate food in the front compartment of the pen.

This study was developed by Mr. Damena Assefa, an Ethiopian graduate student at Bowling Green State University, as the research requirement for his M.A. thesis.

Estimating Postharvest Grain Losses to House Mice

Very little data on postharvest losses caused by rodents have been systematically collected in developing countries, primarily because quantitative techniques to assess losses have not been sufficiently developed for practical field use. The quantitative methods used in this study were reasonably simple and appeared to yield a very acceptable level of precision. In a simulated grain storage area at DWRC, a population of about 15 house mice contaminated wheat with 173 droppings and 454 hairs/kg of bulk-stored wheat over a 5-month period. Urine contamination was highest in the upper 2.5 cm of wheat, but 45% of the wheat was contaminated to a depth of 9.5 cm. Consumption was found to be 6.5 kg or about 2.9 g/mouse/day. Following additional simulated storage studies at DWRC, the techniques will be used to estimate contamination in household storage situations at project field stations.

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[2] Partially funded under a PASA except as otherwise indicated.
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[4] Foreign nationals associated with the project and funded by their respective governments except as otherwise indicated.
[5] Individuals who cooperated with the project in research, extension, or project development activities or who participated as students or trainees.

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4 Mar	Ms. Maria Elena Leon	Venezuela (Student at CSU)
25-27 Apr	Mr. Marcos Peña	Former director, Fish and Wildlife Program, Dominican Republic
13 May	Mrs. Parvin Sultana	BARI, Dhaka, Bangladesh
23 May-21 Jun	Mr. Rogatus K. Z. Mrema	Ministry of Agriculture, Bird Control Unit, Arusha, Tanzania (West Virginia University, Morgantown, WV)
31 May	Ms. Maria Lobo	Plant Protection Division, Ministry of Agriculture, Cape Verde
	Mr. Moussa Sissoko	Plant Protection Division, Ministry of Agriculture, Mali
	Mr. Soumana Sountera	Plant Protection Division, Ministry of Agriculture, Mali
31 May-1 Jun	Mr. Victor F. Amann	USDA/Pakistan, Islamabad, Pakistan
6 Jun 83-16 Jan 84	Mr. Assefe Damena	Ministry of Agriculture, Addis Ababa, Ethiopia
10 Jun	Mr. Jacob Ruegg	Swiss Federal Institute of Technology, Zurich, Switzerland
13-14 Jun	Dr. J. R. Giles	National Parks and Wildlife Service, Sidney, Australia
22 Jul	Mr. Tom Brackney	IRRI, Dhaka, Bangladesh
26 Jul	Mr. Moses Adeola	Nigeria (Student at CSU)

Date	Name	Representing
8-12 Aug	Mr. Thadeus C. Tarimo	National Bird Control Unit, Arusha, Tanzania. Student at California Polytechnic State University
30 Sep	Mr. Abdul H. Wahab	USAID/Haiti
3 Oct	Ms. Julie Savidge Mrs. Tom Seibert	Department of Agriculture, Guam, M.I.
11 Oct	Salva M. Abdel Hameed (Sudan) Nadir M. Awad (Sudan) Damena Assefa (Ethiopia) Paul J. Creeden (USA) Daniel E. De Sousa (USA) David Palmer (USA) Maria E. Leon (Venezuela) Parvin Sultana (Bangladesh)	Students, Vertebrate Pest Management course, Colorado State University, Fort Collins, Colorado
14 Nov	Mr. Avinoam Lourie	Nature Reserves Authority, Wildlife Protection Branch, Haifa, Israel

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GPO 844-259