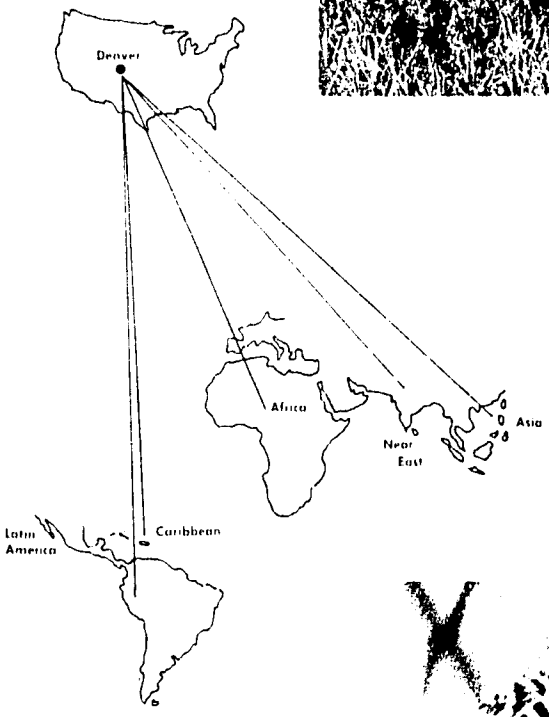
VERTEBRATE DAMAGE CONTROL RESEARCH IN AGRICULTURE

ANNUAL REPORT 1985



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

U.S. Agency for International Development

1985 ANNUAL PROGRESS REPORT[1]

INTERNATIONAL PROGRAMS SECTION
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U.S. Animal and Plant Health Inspection Service[2]

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Agricultural Agencies in Asia, Latin America, and Africa

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[2]The Denver Wildlife Research Center was transferred by Act of Congress from the U.S. Department of the Interior to the U.S. Department of Agriculture on December 19, 1985.

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.

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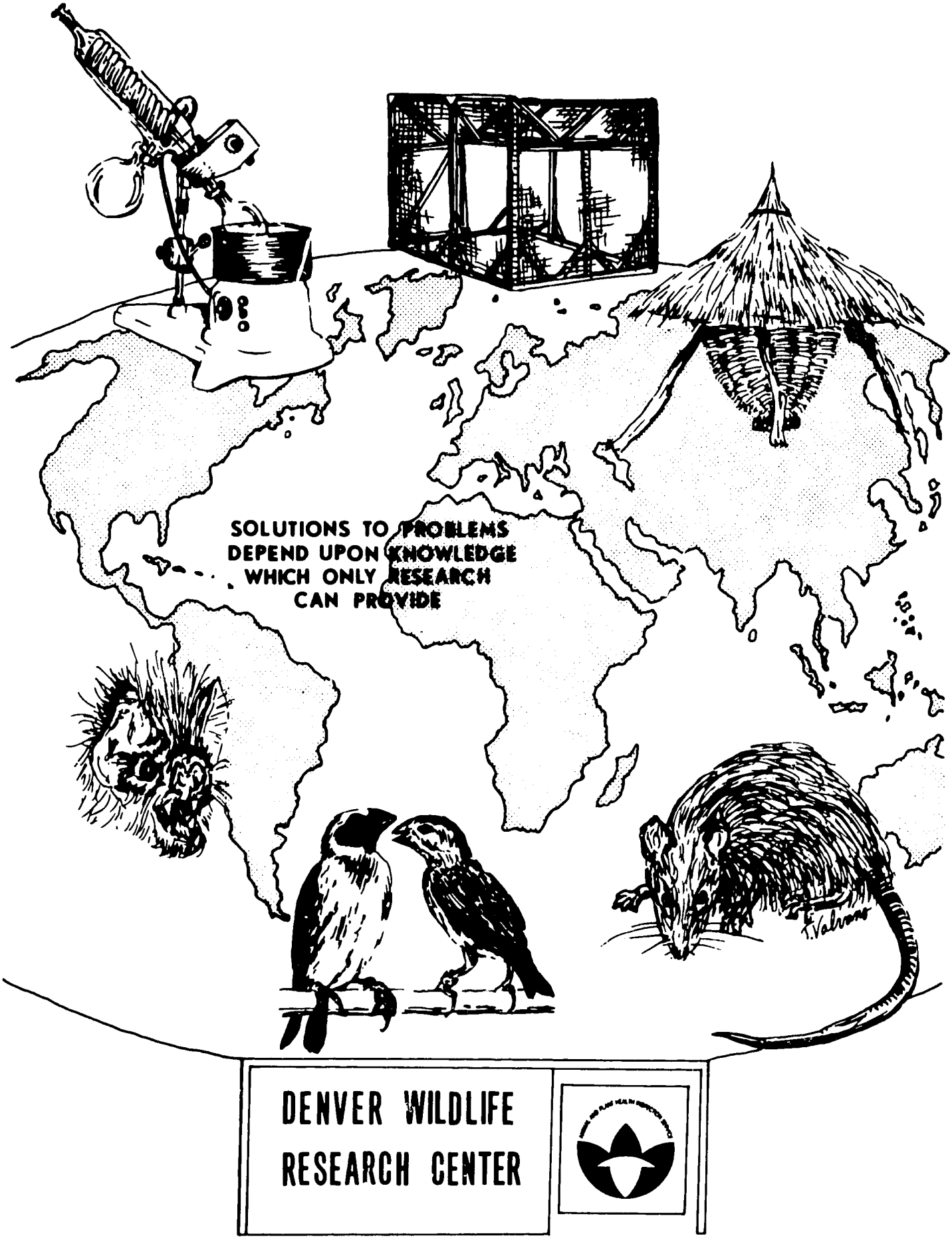
SOLUTIONS TO PROBLEMS
DEPEND UPON KNOWLEDGE
WHICH ONLY RESEARCH
CAN PROVIDE
DENVER WILDLIFE
RESEARCH CENTER

VERTEBRATE DAMAGE CONTROL RESEARCH IN AGRICULTURE

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 DWRC since 1967 under Participating Agency Service Agreements (PASA's) as provided for in Section 632B of the Foreign Assistance Act of 1961, as amended. The 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 Branches of Wildlife Damage Control, Predator Studies, Research Support, 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 International Programs Section of the 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.

Names of birds follow: Clements, J. F. 1978. Birds of the World: A Check List. The Two Continents Publishing Group, Ltd., New York, NY. 532 pp.

Names of mammals follow: Mammal Species of the World: A Taxonomic and Geographic Reference. 1982. Honacki, J. H., Kinman, K. E., and Koeppl, J. W., eds. Allen Press, Inc. and The Association of Systematics Collections, Lawrence, KS. 694 pp.

During 1985, project personnel devoted much time and effort to support field station activities and cooperate with other organizations in research and training of mutual interest.

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 was located in Port-au-Prince, Haiti, and served the specific needs of Haiti and other regional countries. In September 1984, the project leader returned to the DWRC ending 5 years of direct involvement in establishing an effective Vertebrate Pest Laboratory. During 1985, DWRC continued to provide short-term assistance as requested by USAID/Haiti and the Ministry of Agriculture. A survey was conducted to determine rodent activity in agricultural areas on small farms.

Bangladesh

The Vertebrate Pest Control Laboratory (VPCL) continues to be a highly successful research program, and staff are training extension personnel throughout the country. During 1985, a survey of pest birds in rice was conducted. Studies were conducted to determine the effectiveness of three rodenticides in wheat fields; tiller-cutting behavior of the lesser bandicoot rat (*Bandicota bengalensis*) in wheat at different growth stages; simulated bird damage to sprouting wheat; postharvest losses at the farm and village level; jackal damage to crops and livestock; and studies were initiated on the biology and agricultural importance of the short-tailed mole rat (*Nesokia indica*).

In October, the Project Leader of VPCL was transferred to Islamabad, Pakistan, to initiate a vertebrate pest control program in that country. A new Project Leader will commence his assignment in Bangladesh mid-1986. In the meantime, several temporary duty assignments (TDY's) are scheduled to continue field and laboratory studies.

Pakistan

The Vertebrate Pest Control Project (VPCP) was established on October 30, 1985, with the arrival of the Project Leader in Islamabad. The project is a subcomponent of the Food Security

Management (FSM) Project, under the Post-Harvest Management (PHM) component and is under direct coordination of the Joint Secretary for Food in the Federal Ministry of Food and Agriculture (MINFA). The MINFA Food Division also coordinates the implementation of the PHM component through the Provincial Food Departments (PFD's), Pakistan Agriculture Storage and Supply Company (PASSCO), and Pakistan Agricultural Research Council (PARC). Temporary office space at the National Agricultural Research Centre (NARC) in Islamabad will be made available early January; laboratory space will not be available until the completion of the new laboratory wing in mid-1986.

Objectives of the VPCP are:

Strengthen capabilities of PARC vertebrate pest control laboratories at Karachi and Islamabad and to upgrade the applied research program in the control of birds and rodent in stored grains.

Strengthen capabilities of the four PFD's at Sind, Punjab, Baluchistan, and North West Frontier in vertebrate pest control operations and loss assessment methods in their grain storage facilities.

Strengthen the PASSCO in vertebrate pest control operations and loss assessment methods in their food storage facilities.

Improve the quality of adaptive research programs for stored grains.

Assess the problems of vertebrate pest-caused losses of stored grains at farm level and devise means of reducing such losses.

Assess major vertebrate pest problems in preharvest crop losses and attempt to implement operational pest control in pilot and large-scale trials.

During 1985, the 5-year Vertebrate Pest Control Program in Haiti was terminated. The Vertebrate Pest Control Laboratory in Bangladesh continued its research program. A new Vertebrate Pest Control Project was established in Pakistan. The broad goals of these programs are to increase food production and reduce the risk of severe agricultural losses caused by vertebrate pests in developing countries. Special objectives are:

Establish the technical capabilities and support within governments and the agricultural sector to conduct programs in vertebrate pest research and management.

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.

Provide onsite training in research and management methods to reduce losses by vertebrate pests.

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

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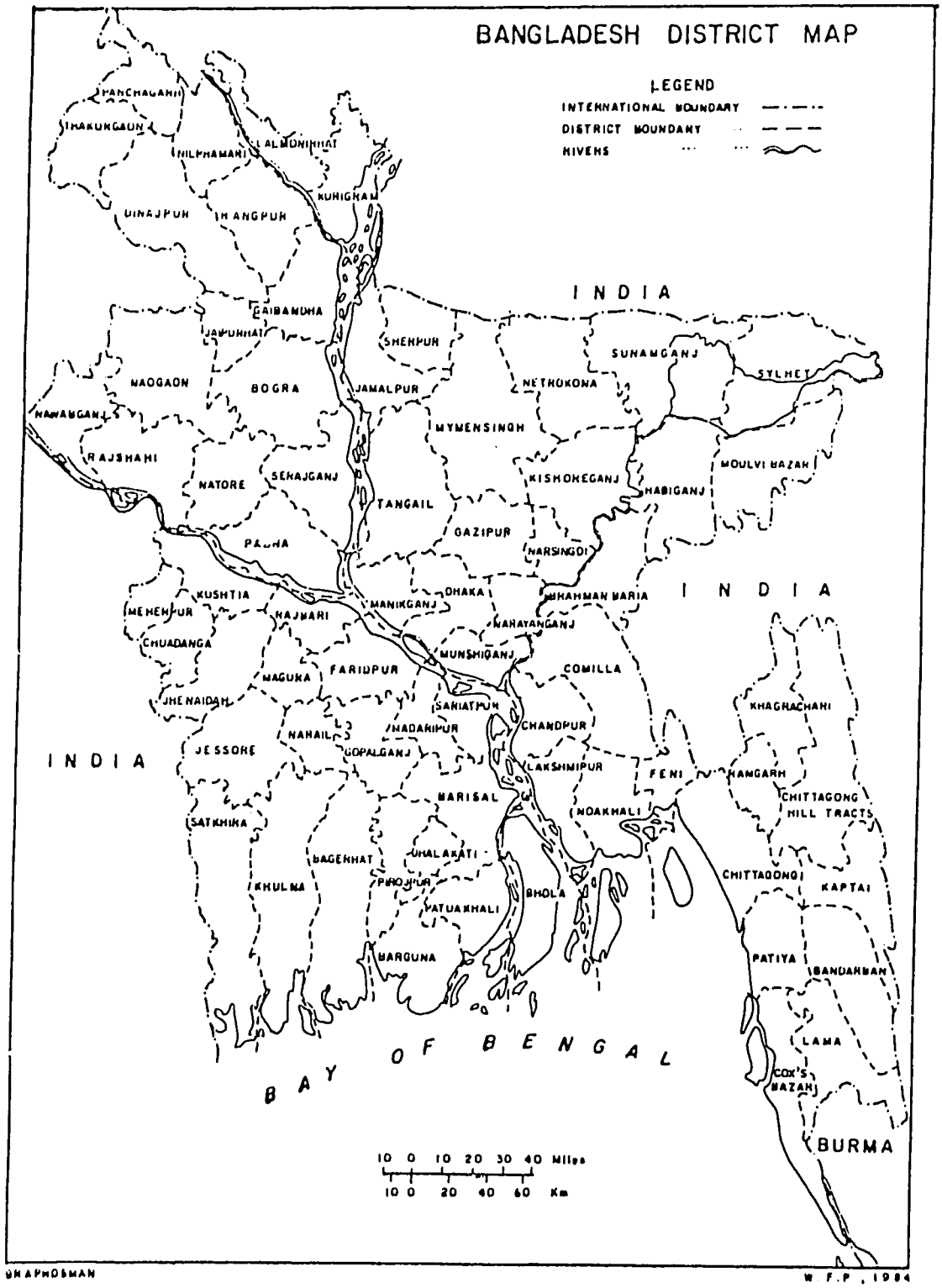

BANGLADESH DISTRICT MAP
LEGEND
INTERNATIONAL BOUNDARY
DISTRICT BOUNDARY
RIVERS
INDIA
INDIA
INDIA
BURMA
BAY OF BENGAL
PANCHAGARH
THAKURGAON
NILPHAMARI
LALMONIRHAT
KURIGRAM
DINAJPUR
RANGPUR
GAIBANDHA
JAMALPUR
SHERPUR
SUNAMGANJ
SYLHET
NAOGAON
BOGRA
JAMALPUR
NETROKONA
NAWABGANJ
MYMENSINGH
RAJSHAHI
NATORE
SIRAJGANJ
KISHOREGANJ
HABIGANJ
MOULVI BAZAR
TANGAIL
GAZIPUR
PABNA
NARSINGDI
KUSHTIA
MANIKGANJ
DHAKA
BRAHMANBARIA
MEHERPUR
RAJBARI
NARAYANGANJ
CHUADANGA
MUNSHIGANJ
COMILLA
MAGURA
FARIDPUR
JHENAIDAH
SARIATPUR
KHAGRACHARI
NARAIL
MADARIPUR
CHANDPUR
JESSORE
GOPALGANJ
LAKSHMIPUR
FENI
RANGARH
BARISAL
CHITTAGONG HILL TRACTS
NOAKHALI
SATKHIRA
BAGERHAT
JHALAKATI
CHITTAGONG
KHULNA
PIROJPUR
BHOLA
KAPTAI
PATUAKHALI
BARGUNA
PATIYA
BANDARBAN
LAMA
COX'S BAZAR
10 0 10 20 30 40 Miles
10 0 20 40 60 Km
DRAFTSMAN
W.F.P. 1984

BANGLADESH

Vertebrate Pest Problems in Bangladesh

The following summary (Table 1) was compiled to give a brief overview of vertebrate pests in Bangladesh and the damage they cause.

Table 1. Major and minor pests causing damage in agricultural crops, farm structures, and livestock in Bangladesh.

Common name	Scientific name	Damage
	RODENTS	
Major pests		
Lesser bandicoot rat	*Bandicota bengalensis*	Wheat and rice fields; houses and godowns
Greater bandicoot rat	*Bandicota indica*	Deepwater rice; swamps
Roof or house rat	*Rattus rattus*	Sugarcane fields; houses
House mouse	*Mus musculus*	Houses and godowns
Minor pests		
Short-tailed mole rat	*Nesokia indica*	Root crops
Striped squirrel	*Funambulus pennanti*	Coconut; rice seed beds
Asiatic porcupine	*Hystrix hodgsoni*	Root crops; pineapple
	BIRDS	
Major pests		
Common myna	*Acridotheres tristis*	Sprouting wheat
Pied myna	*Sturnus contra*	Sprouting wheat
Rose-ringed parakeet	*Psittacula krameri*	Maize; sunflower
Junge crow	*Corvus macrorhynchos*	Maize; sunflower; watermelon
Baya weaver	*Ploceus philippinus*	Rice
House sparrow	*Passer domesticus*	Rice; wheat
Munias	*Lonchura* spp.	Millet
	CARNIVORES	
Major pests		
Golden jackal	*Canis aureus*	Sugarcane; maize; melons; goats; chickens
Small Indian mongoose	*Herpestes auropunctatus*	Chickens
Minor pests		
Civet cat	*Viverra zibetha*	Chickens
Jungle cat	*Felis chaus*	Chickens

Losses in Bangladesh Agriculture Caused by Vertebrate Pests

Vertebrate pests, mainly rats, mice, birds, and jackals cause losses to food grains, other field crops, livestock, and stored food. From surveys and studies carried out by the staff of the VPCL, Bangladesh Agricultural Research Institute (BARI), during the past 6 years, the following estimated crop and livestock losses caused by vertebrate pests in Bangladesh were determined (Table 2).

Table 2. Losses in agriculture caused by vertebrate pests, Bangladesh.

Affected crops and livestock	Observed yield (t)	Damage	Estimated yield loss (t)	Estimated loss (US $)
		Rats and mice (studies conducted during 1983 and 1985)		
Rice				
Aus	3,018,000	1.5%	46,000	8,433,300
Aman	7,483,000	5.0%	393,800	72,197,000
Boro	3,490,000	3.5%	127,000	23,283,300
Wheat	1,078,000	4.5%	51,000	5,780,000
Stored foods (paddy)		50 kg/farm/ family/year	600,000	110,000,000
		Jackals (studies conducted during 1984 and 1985)		
Field crops				91,200,000
Livestock				29,342,300
Poultry				44,955,300
		Birds (studies conducted during 1983)		
Wheat (sprouting)		17.0%	220,000	24,933,300
Wheat (maturing)		0.5%	5,400	600,000
Total losses				410,724,500

Countrywide Bird Pest Survey

A farmers' questionnaire survey of problems caused by pest birds was conducted jointly by the Bangladesh Rice Research Institute (BRRI) and BARI in 44 districts and 145 upazilas in Bangladesh between 22 April and 27 May 1985. This was a countrywide survey of insects and bird pests of rice and rice diseases during the boro rice season.

We contacted 569 farmers. Of 557 farmers who responded, 64.6% said they had bird problems. The heaviest damage (77.2%) occurred in the aman rice season, the least (5.2%) in the aus. Approximately 84% of the farmers who encountered bird problems made efforts to control damage. Most farmers (94.3%) employed bird scarers; 3% used scarecrows. Of the 557 farmers who took part in the survey, four used guns, two used firecrackers, and one used nets. When asked whether new bird control methods needed to be developed, 81.3% said yes. According to farmers' responses, birds attack fields in the morning (45.8%), in the afternoon (53%), and midday (1.3%). Only 26% considered birds to be a severe pest problem in their area, while 40.3% regarded birds as a minor pest problem.

Wild ducks, pigeons, parakeets, weaver birds, and house sparrows were the most destructive bird pests of seed bed rice. In ripening rice, mainly weaver birds, parakeets, house sparrows, wild ducks, munias, common mynas, and house crows were observed by farmers. Sprouting wheat was attacked by pied mynas, common mynas, jungle crows, jungle mynas, house crows, and rock pigeons. Six farmers reported squirrels were a problem in sprouting wheat. Ripening wheat seemed to be less susceptible to bird damage.

Trapping Golden Jackals (*Canis aureus*)

Trapping provides a technique for obtaining animals for study, as well as a potential means of controlling damage by removing problem animals. A goal of initial trapping efforts was to obtain sufficient animals for the BARI kennels to begin trials with candidate baits and toxicants. Fieldwork was begun as soon as the kennel facilities had been prepared for holding jackals.

No. 1.75 Woodstream Soft Catch^R Fox Traps were used for all trapping. These traps had rubber jaw pads that were anticipated to minimize injury to animals being held for further study. Although the weather was dry throughout this trapping period, the technique of rust-proofing traps with ZRC^R, a cold galvanizing compound, was demonstrated, and all traps were treated before use. Protecting traps in this manner will help extend the life and working condition of traps to be used in the generally wet, humid climate of

Fieldwork with jackals in Bangladesh often attracts the enthusiastic participation of villagers.

Bangladesh. The use of cold galvanizing to rustproof traps was developed at DWRC.

Initial trapping efforts were conducted in sugarcane fields in the Gazipur District near Joydebpur. V-sets were used based on earlier success with this technique in the Ishurdi area. Cane stalk debris was formed in a V along a trail in the field near recent jackal damage, so that a trap could be approached from only one direction. A trap was set in a shallow dirt hole within the V. The trap pan was covered with strips of cane leaves or with a square of thin, plastic film to prevent dirt from blocking the trap mechanism. Then dirt was sifted over the trap so that the pan was covered by a thin layer. A small amount of scent, prepared by emulsifying canned sardines in water, was placed at the point of the V, approximately 15 cm from the trap pan. Traps were affixed to the ground using 60-cm metal pins pounded flush with the ground surface, and the entire site was concealed with sifted dirt.

Over the course of 2 days, 18 traps were set in this manner, 16 in cane fields and 2 near pans that were being established to prepare molasses, locally known as gur, from harvested cane. Table 3 summarizes the results of this trapping. Traps were lost or removed, presumably by local villagers anxious to participate in jackal control, nearly as quickly as they could be set, and no jackals were captured. The occasion created by the visit of BARI researchers, accompanied by foreigners to the villages to trap jackals, invariably drew a considerable crowd, and concealing of traps was not effective in reducing disturbance. A different technique was obviously required.

Table 3. Summary of trapping in and around sugarcane fields in Gazipur District, Joydebpur Upazila, Bangladesh, 28-31 January 1985.

Total traps	18
Trapnights	24
Sprung, no capture	1
Missing traps	6
Carnivore tracks near trap	8
Dogs	2
Cat	1
Common babbler	1
Mongoose	1

A 12-space kennel facility for holding jackals was constructed in the Vertebrate Pest Control Laboratory compound on the Bangladesh Agricultural Research Institute campus.

Since farmers would ultimately be involved in any control effort, the approach of training farmers to trap, making each cooperating farmer responsible for setting and guarding a few traps, was adopted. This approach worked well, and the numbers of lost traps declined immediately.

While trapping cane fields, we noted that most areas of jackal damage were at least a few days old. In the course of talking with farmers about trapping, it was learned that considerable jackal activity was occurring at the sites of molasses preparation, where the juice from freshly harvested cane was boiled. Sugar residue and debris were skimmed from the surface of the boiling pans and placed beside the firepit throughout the day. When the sugar-processing activities stopped for the night, jackals would visit those sites to lick this sweet residue. The change in jackal activity, associated with the beginning of the sugarcane harvest and the preparation of gur, explained our observation that little fresh damage was occurring in the cane fields we had trapped. At the farmers' recommendations, most of the trapping effort was concentrated at the boiling pan sites, which were numerous throughout the district. The results of trapping by trained farmers are shown in Table 4.

Table 4. Summary of trapping by trained farmers at eight sites around sugar-boiling pans and in cane fields in Gazipur District, Joydebpur Upazila, Bangladesh, 30 January to 7 February 1985.

	Boiling pans	Cane fields	Total
Trapnights	125	41	166
Jackals	10	1	11
Dogs	0	4	4
Foxes	2	0	2
Mongoose	0	1	1
Small Indian civet	0	1	1
Traps sprung, no capture	7	0	7

When molasses is prepared from sugarcane in village areas, jackals visit the sites to lick the sweet residue left beside the boiling pans.

The results of these two trapping exercises indicated that, at this particular time, jackals and Bengal foxes were active at the gur sites, while most of the activity along cane field trails involved a variety of other animals. Any successful trapping effort, whether for collecting animals for laboratory work or for purposes of control, would need to be focused on areas where jackals are active at a particular time and place. These areas of jackal activity undoubtedly change frequently during the course of a year, depending on village activities and crop conditions. Frequent discussions with farmers and careful observation of the patterns of crop damage by jackals are probably the simplest means of determining these changing annual patterns.

The rapidity with which jackals shifted their activity from the cane fields to the molasses preparation sites provides several leads that may be useful both for further study of animals and in the development of control techniques. Sweet materials, including sugar and sugarcane, are a common component of the jackal diet during some parts of the year in much of Bangladesh, and apparently the sweet taste is attractive. This may provide a means of enhancing the acceptance of baits, if this technique is developed for control. Likewise, a technique using licking posts treated with the residues from sugar preparation might be investigated as a means of delivering chemicals. Use of "molasses dumps" as draw stations might prove useful at any time of the year to concentrate the activity of jackals for study or for control.

Immobilization of Golden Jackals With Ketamine

Ketamine hydrochloride was tested as a field immobilizing agent while trapping golden jackals from sugarcane-growing areas in central Bangladesh. Further studies were carried out on jackals held in captivity for periods of 1-5 months. Recent studies have indicated that ketamine hydrochloride is a valuable anesthetic and immobilizing agent when dealing with small- to medium-sized carnivores. This material is particularly useful in the field because it can be injected intramuscularly, takes effect quickly, and has a wide safety margin. Ketamine also has been used in combination with other agents, mainly muscle relaxants such as xylazine and acetylpromazine. These combinations generally give a deeper and longer anesthetic effect than that of ketamine alone.

Jackals were captured with No. 1.75 coil-spring traps with padded, offset jaws. Trapped jackals were injected intramuscularly in the hip with ketamine hydrochloride (Ketaset^{R}, Bristol Laboratories, Syracuse, N.Y.). Each jackal was weighed, sexed, and transported within the hour to holding pens at BARI, Joydebpur, about 20-25 km south of the trapping area.

The first six captured jackals were injected with a mean dosage of 12.6 mg/kg of ketamine; mean recovery time was 69 min (range 28-120 min). Five more jackals were injected with a mean dosage of 22.8 mg/kg of ketamine, and the mean recovery time was 92.4 min. Time to immobilization varied considerably among jackals, ranging from 80 to 360 s and averaging 158 s. There appeared to be no relationship between the dosage injected and the rapidity of immobilization. Jackals remained with their eyes open and pupils dilated, but were able to blink. The muscles were relaxed and animals could be handled with ease. Breathing was slow and regular. Copious salivation set in with immobilization and continued in some animals until recovery. One jackal died 3.5 h after injection, apparently from respiratory failure. It showed mild convulsions during the hour preceding death. This animal had been captured and tightly restrained by villagers and was overheated when injected.

Additional tests were conducted with caged jackals using various doses of ketamine. Injections ranged from 1 to 3 mL per animal. Findings indicated a strong correlation between dosage and recovery time ($r = 0.8994$, $P < 0.01$, $Y = 1.965 + 3.249X$). Jackals receiving a mean dosage of 14.8 mg/kg of ketamine recovered in an average of 49 min, considerably faster than recently captured animals. Much of this difference was probably due to the excitement of animals restrained in traps. Every trapped jackal attracted a small group of children and adults who were in attendance for an hour or more before our arrival.

Jackals immobilized with ketamine should be kept in the shade, since the eyes remain open and the pupils are dilated. They should be kept cool to prevent overheating. We noted no adverse reactions to transporting them to the laboratory approximately 1 hour after injection. The use of ketamine hydrochloride to immobilize and handle golden jackals was entirely satisfactory and safe. The death of one jackal was complicated by factors other than the ketamine injection. Based upon our results, we recommend a dosage of between 10-15 mg/kg as being adequate for most field or laboratory situations when working with this species.

Tiller-cutting Behavior of *Bandicota bengalensis* in Wheat at Different Growth Stages

Each year, wheat fields in Bangladesh suffer rat damage. Little information is available on the capability of individual animals causing crop damage by cutting wheat tillers and the interaction of the different growth stages of wheat that might affect the tiller-cutting behavior of rats.

A study to observe the tiller-cutting behavior of the lesser bandicoot rat (B. bengalensis) on wheat plants was conducted at BARI in a rodent-proof outdoor enclosure. Four female bandicoot rats were released into subenclosures (7.3 x 11 m in size) at three growth stages--booting, flowering, and maturing--of wheat. At the end of each observation period, rats were captured and removed to holding cages until the next phase of the experiment. The total number of cut and uncut wheat tillers in each subenclosure was counted in each square meter at the end of each exposure period. Rats cut most tillers during the booting stage (89.4/rat/night); this decreased consistently from 71.7 tillers/rat/night at the flowering stage to 25.1 tillers/rat/night at maturing (Table 5). There was good negative correlation between crop stages and the average number of tillers cut per night ($r = -0.81$, $P < 0.05$; Fig. 1). At the booting stage, rats were cutting tillers and tearing away the leaf sheaths to eat the newly forming immature panicles. This behavior was not observed at the flowering stage. Rats established runways 2-3 days after release into the enclosures during all growth stages. No special relationship between the cut tillers and runways was observed. Most of the damage was done at night. Rats failed to maintain their body weight at both booting and flowering stages, but gained an average of 20% of their weight in the maturing stage during 17 days in the subenclosure.

Table 5. Enclosure study of number of tillers cut by Bandicota bengalensis at several growth stages of wheat, BARI, Joydebpur, 1985.

Growth stage	Days after sowing	Avg. no. tillers cut/rat/night: 5-night observation period	Avg. no. tillers cut/rat/night: Cumulative for each growth stage
Booting	47- 52	89.4	89.4
Flowering	58- 63	92.2	71.1
	63- 68	50.0	
Maturing	98-103	3.7	25.1
	103-108	27.0	
	108-113	44.5	

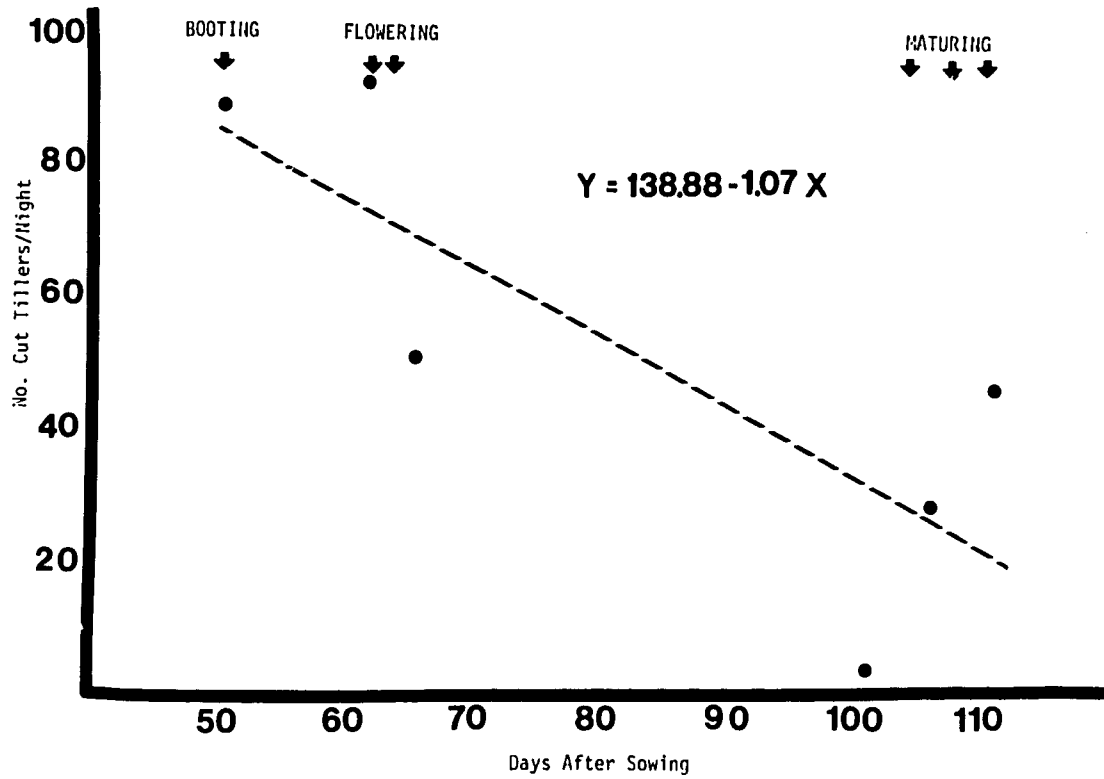


Fig. 1. Regression line showing the relationship between growing stage of wheat and the number of tillers cut per night by Bandicota bengalensis during enclosure trial, BARI, Joydebpur, 1985.

The implications for rat control in wheat are that baiting should be done at tillering to booting stage to effectively reduce damage. Baits should also compete favorably with the wheat at this time. Baiting during later crop growth stages is uneconomic and most likely will not reduce yield losses.

Comparison Trials of Three Rodenticides in Wheat Fields

On 2 February, comparison trials of three rodenticides, 0.005% bromethalin, 0.005% brodifacoum, and 0.0375% coumatetralyl were begun in farmers' wheat fields near Kaliakair, about 30 km west of Joydebpur. On 9 March, damage assessments in 50, 50 x 50-cm quadrats were made in untreated and treated areas. Damage assessment results are given in Table 6. Before and after each treatment, 40 tracking tiles were placed at 20- to 30-cm intervals on transects in each area and rodent activity was measured. Baits of each

rodenticide were placed near or inside each rat burrow in wheat fields for 3 consecutive nights three times during the study. Data on tracking tile activity and active burrows during each poisoning period are given in Table 7.

Table 6. Rat damage assessment data in rodenticide-treated farmers' wheat fields compared to untreated field, near Kaliakair, Bangladesh, 1985.

Treatment	Study area (m^2)	Total no. stems	No. stems cut	% damage	Damage decrease (%)
Reference	5,552	2,704	49	1.78	-
Bromethalin	7,960	3,159	54	1.68	5.6
Brodifacoum	7,546	3,247	48	1.46	18.0
Coumatetralyl	4,804	3,361	27	0.80	55.1

Table 7. Tracking tile activity and active burrows in rodenticide-treated wheat fields compared to untreated field, near Kaliakair, Bangladesh, 1985.

	Treatment							
	Coumatetralyl		Brodifacoum		Bromethalin		Reference	
Crop stage	% pos. tiles	No. active burrows	% pos. tiles	No. active burrows	% pos. tiles	No. active burrows	% pos. tiles	No. active burrows
Flowering	45.0	23	40.0	4	30.0	10	12.5	13
Ripening	40.0	15	25.0	15	40.0	11	22.5	12
Mature	12.5	4	17.5	5	22.5	12	17.5	10

The plot baited with coumatetralyl had a 55% reduction in damage as compared to reference, an 82.6% reduction in active rat burrows, and a 72.2% decrease in tracking tile activity. Brodifacoum and bromethalin plots showed little difference from the reference in all measures. Damage in all plots, including reference, was low. Additional studies are required to understand how results with these compounds may be improved.

Studies on the Biology and Agricultural Importance of *Nesokia indica*

A study on the biology, distribution, and agricultural importance of the short-tailed mole rat, *Nesokia indica*, was initiated and will be carried out over a 1-year period.

Mole rats were trapped from several habitats at Ishurdi and Muladuli, Pabna District, using gopher traps. During 3 days of trapping, 61, *N. indica* and 2 *Bandicota bengalensis* were captured (Table 8). Most *N. indica* were trapped from burrows in ditchbanks, although some were captured from harvested wheat fields and fields of sweet potato, gram, and sugarcane.

Table 8. Capture of burrowing rodents using gopher traps in Pabna District, Bangladesh, 1985.

	Crop type or habitat					
	Wheat		Sweet			Dikes and
Trap site	Maturing	Harvested	potato	Gram	Sugarcane	ditches
Ishurdi	10/5[a]	15/0	5/2	5/2	0	94/26
Pabna	0	0	0	5/3	0	53/21
Muladuli	0	0	0	0	9/4	0
Total	5	0	2	5	4	47

[a]Trap days/capture.

Feeding preference studies using cereal grains and root crops showed that paddy and milled rice were about equally consumed and preferred over maize (Table 9). Sweet potato was preferred over carrot, and carrot over potato (Table 10).

Table 9. Feeding preference of *Nesokia indica* for cereal grains.[a]

Animal			Mean daily consumption (g)			
No.	Sex	Weight (g)	Rice	Maize	Paddy	Total
1	M	290	3.4	6.1	4.1	13.6
2	M	283	9.9	1.2	3.8	14.9
3	M	324	12.0	1.9	7.4	21.3
4	F	135	0.2	1.3	11.0	12.5
Total			25.5	10.5	26.3	62.3

[a]Three-day offering of three foods.

Table 10. Feeding preference of *Nesokia indica* for root crops.[a]

Animal			Mean daily consumption (g)			
No.	Sex	Weight (g)	Carrot	Sweet potato	Potato	Total
1	M	318	15.1	56.0	10.4	81.5
2	M	299	41.3	17.5	7.6	66.4
3	M	340	22.9	43.3	14.2	80.4
4	F	141	15.5	37.1	5.4	58.0
Total			94.8	153.9	37.6	286.3

[a]Three-day offering of three foods.

In May, additional mole rats were trapped at Ishurdi, Pabna District, and Varamara, Mirpur, and Kustia Sadar upazilas in Kustia District, for reproductive and food habit studies. Mole rats trapped at Mirpur and Kustia Sadar upazilas were the first records of the existence of this species in Kustia District south of the Ganges River. In June, collections of mole rats were attempted in Rasulpur and Mokamtale upazilas in Bogra District, but burrows contained only *B. bengalensis*.

Studies on the reproductive condition of captured female mole rats were initiated to determine the annual cycle of reproduction (Table 11). Highest percentages of pregnant females occurred in the period December to February; lowest percentages occurred in May and June.

Table 11. Monthly percentage of captured pregnant female short-tailed mole rats, Bangladesh.

Month captured	% pregnant
Apr 1985	12
May	4
Jun	0
Jul	18
Aug	21
Sep	18
Oct	30
Nov	40
Dec	42
Jan 1986	42
Feb	46
Mar	26

Additional studies of this species are continuing in 1986.

Wheat Yield Reduction Through Simulated Bird Damage at the Sprouting Stage

Wheat is the second major food grain crop in Bangladesh. With the introduction of high-yielding varieties, wheat production rapidly increased throughout the country during the past decade. Increased production resulted in increased pest bird damage to wheat at the sprouting stage. The most important pest bird species damaging sprouting wheat in Bangladesh are common myna (*Acridotheres tristis*), Asian pied starling (*Sturnus contra*), large-billed crow (*Corvus macrorhynchos*), house crow (*C. splendens*), rock dove (*Columba livia*), collared dove (*Streptopelia decaocto*), and house sparrow (*Passer domesticus*).

A study to determine simulated bird damage to sprouting wheat (16 days after sowing) utilizing a randomized block design was conducted in a farmer's field in Gazaria Upazila on a 13.5 x 13.5-m experimental area. The study plot was divided into five blocks; each block was divided into five plots for a total of 25 plots. Each plot measured 2 x 2 m and was separated by pathways 0.5 m wide. The plots were marked with bamboo sticks and numbered tags.

The experiment consisted of five replications with five damage intensities--0% (reference); 10, 20, 30, and 40% sprout removal. Within each plot, plants were counted and a fixed number (800/plot) was retained. Then the appropriate percentage of sprouts was randomly removed as simulated bird damage.

The Balaka wheat variety was sown at the rate of 50 kg/ha on 7 December 1984; sprouts were removed on 23 December to meet the required counts. Plots were fertilized and weeded. Individual plots were harvested on 14 March 1985, 98 days after sowing. Panicles were tied into bundles and stored separately. Bundles were spread individually to sun-dry and were then hand-threshed. Panicles in each plot were counted, and the yield of each plot was weighed to the nearest 0.1 g. Statistical analysis was done with analysis of variance and Duncan's Multiple Range Test.

The difference in yield at different damage levels is shown in Table 12. There was an excellent negative correlation ($r = -0.9642$, $P < 0.01$) between damage intensity and wheat yield (Fig. 2). The plant population compensated for the damage by increased tillering. This resulted in more stems per subplot than the initial level after sprout removal. Plant population increased from 66.6 to 112.1% over the original number of plants left as the base level for damage intensities (Table 12). Yield reduction gradually decreased with the increase of percent damage (sprout removal), but in proportion to damage level, the yield loss was less (Table 12). This may be attributed to several reasons, including tiller compensation, more photosynthetic activity due to increased space and light, and greater nutrient and water intake from the soil.

Similar results were obtained in our first simulated bird damage experiment in 1983, where a significant difference was noted between the reference plots and those receiving 30 and 50% damage intensities. Yield loss in 1983 was 14.4% at 30% sprout removal and 19.0% at 50% sprout removal. In the 1984 simulated bird damage experiment, panicle counts at harvest showed good negative correlation with damage intensities, but yield samples indicated no relationship. We suspected that samples were mislabeled. However, all three experiments have given a consistent relationship between the intensity of sprout removal and the resulting decrease in yield.

Table 12. Effect on wheat plant population and yield at different levels of simulated bird damage, Gazaria Upazila, Bangladesh, 1985.

Treatment (% sprout removal)	No. sprouts remaining/plot	Plant population		Yield	
		Mean panicle count/plot	% increase	Mean yield/plot (g)	% decrease
0	800	1,332.6	66.6	1,317.0	-
10	720	1,229.6	70.8	1,182.4	10.3
20	640	1,145.2	78.9	1,137.8	13.6
30	560	1,100.8	96.6	1,105.2	16.0
40	480	1,018.2	112.1	1,036.6	21.3

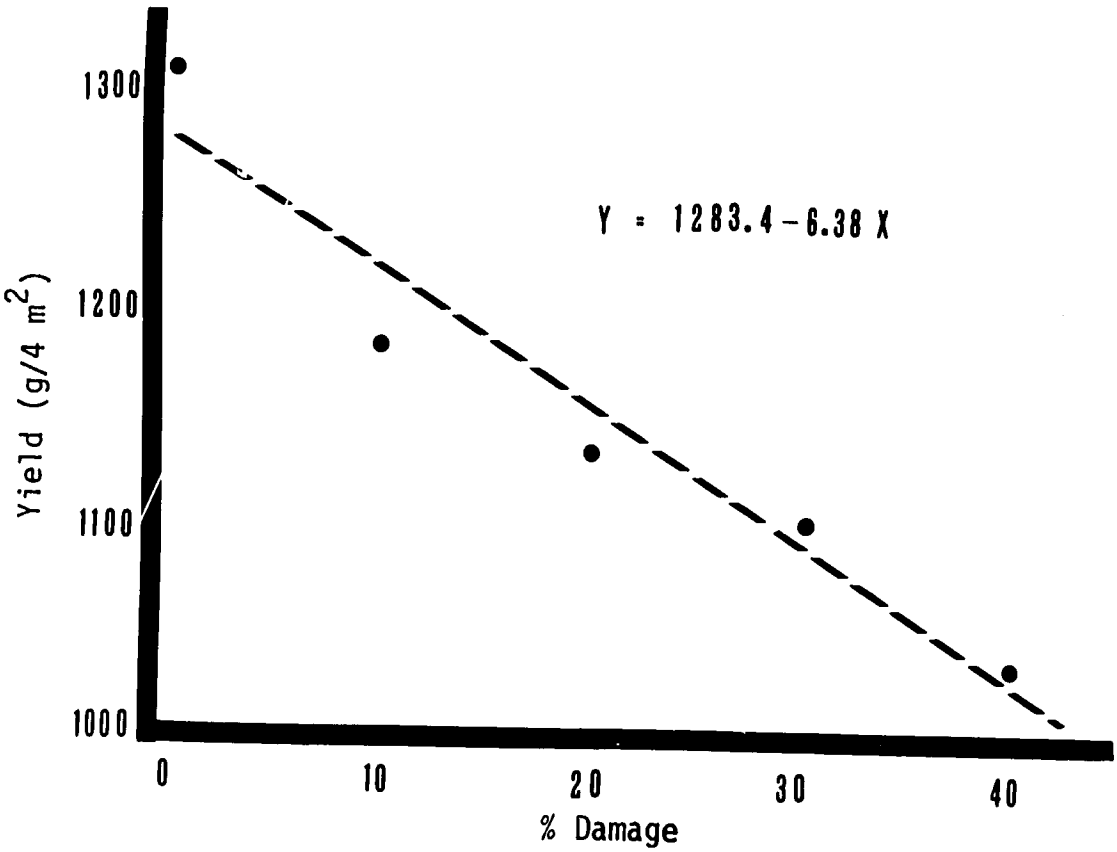


Fig. 2. Yield loss of wheat at several intensities of simulated bird damage at sprouting stage.

Personnel and Training

Mrs. Parvin Sultana completed her Ph.D. degree at Colorado State University, Fort Collins, Colorado, and returned to Bangladesh in October. Her dissertation was on "Factors affecting the performance of bird control chemicals." Mr. Rajat Pandit started graduate studies on an M.S. degree at the University of the Philippines at Los Baños in October. Mr. Emdadul Haque continued his postgraduate studies at Dhaka University. His research topic is "The biology, agricultural importance, and control of the short-tailed mole rat, *Nesokia indica*, in Bangladesh."

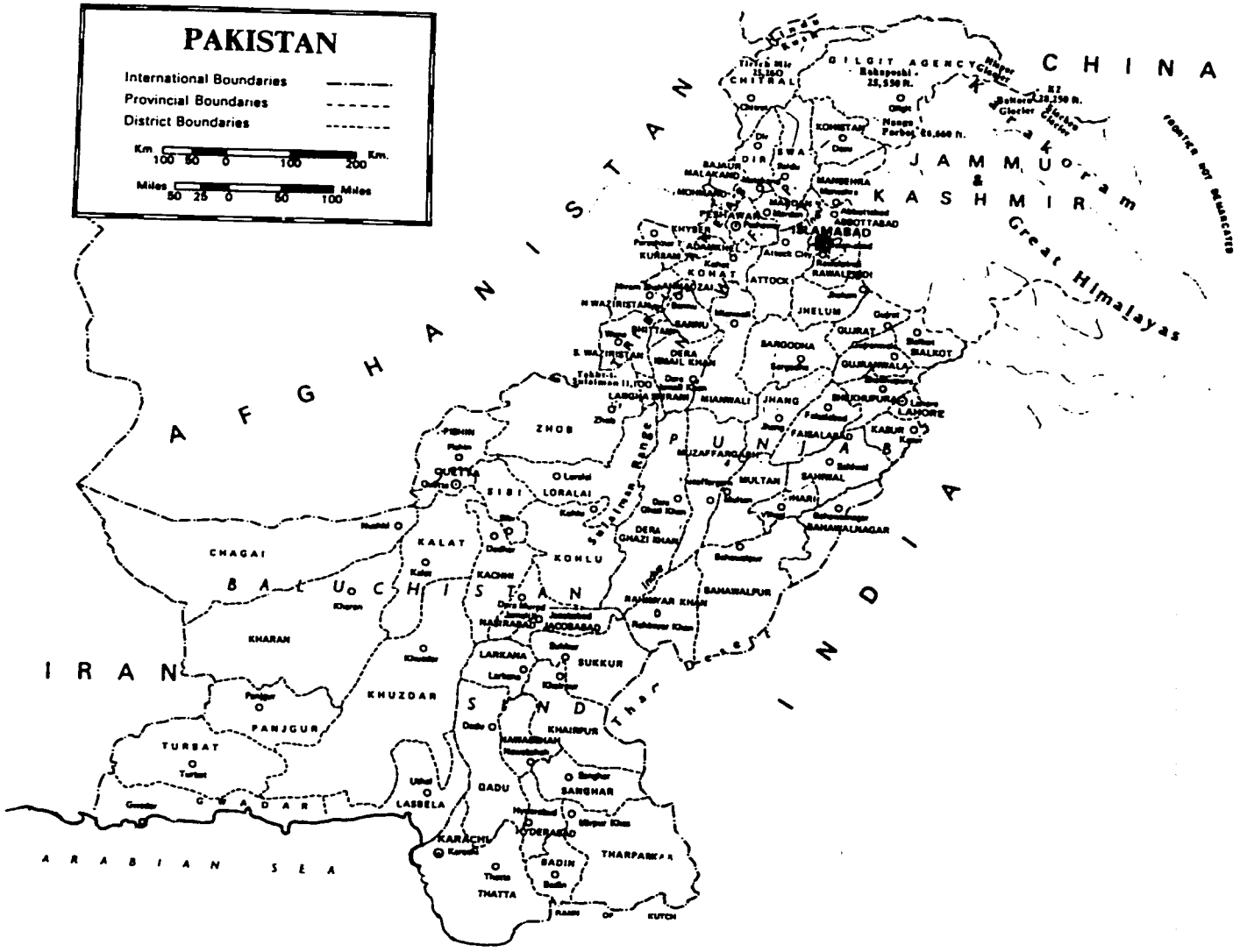
In January and February, two radio talks on pest management topics were broadcast in Bengali language on the Bangladesh Broadcasting System by counterpart staff of the VPRL: M. E. Haque "Bird damage in wheat and its control" and S. Ahmad "Bird damage in maize and its control."

Counterpart staff attended a 1-week Short Course in Experimental Design at BARI, Joydebpur, 9-14 February. During April, half-day

seminars in Vertebrate Pest Research and Management in Bangladesh were presented to 37 scientists at BARI Regional Agricultural Research Station, Ishurdi, and to 137 staff and students at the Agricultural Extension Training Institute, Ishurdi.

Cooperation With National and International Organizations

The VPCL has maintained cooperative ties with a number of national and international agencies. VPCL staff is working with BARI and BRRI on cooperative studies and field trials in rice crops. The VPCL cooperated in postharvest stored food loss studies with the Food and Agriculture Organization of the United Nations (UNDP/FAO)/BRRI Project on assessment of losses of stored paddy at the farm and village level. Other agencies worked with include the British Overseas Development Agency at BRRI, the Bangladesh Ministry of Food, the Bangladesh Sugar Research Institute, Cooperative for American Remittances to Everywhere, Inc. (CARE), and the Australian-Bangladesh Sugar Industry Project at Muladuli.


PAKISTAN
International Boundaries
Provincial Boundaries
District Boundaries
Km
100 50 0 100 200
Km.
Miles
50 25 0 50 100
Miles
CHINA
AFGHANISTAN
IRAN
INDIA
ARABIAN SEA
JAMMU & KASHMIR
Great Himalayas
GILGIT AGENCY
CHITRAL
KOHISTAN
SWAT
DIR
BAJAUR
MALAKAND
MARDAN
MANSEHRA
ABBOTTABAD
ISLAMABAD
PESHAWAR
KHYBER
KURRAM
KOHAT
ATTOCK
RAWALPINDI
JHELUM
GUJRAT
SARGODHA
GUJRANWALA
SIALKOT
LAHORE
SHEIKHUPURA
KASUR
FAISALABAD
JHANG
MIANWALI
BANNU
DERA ISMAIL KHAN
ZHOB
PISHIN
QUETTA
SIBI
LORALAI
MUZAFFARGARH
MULTAN
SAHIWAL
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DERA GHAZI KHAN
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BAHAWALPUR
RAHIMYAR KHAN
NASIRABAD
JACOBABAD
SUKKUR
LARKANA
KHAIRPUR
KHARAN
KHUZDAR
PANJGUR
TURBAT
GADU
SANGHAR
LASBELA
KARACHI
HYDERABAD
BADIN
THARPARKAR
THATTA
RANN OF KUTCH
Thar Desert
Indus
Sulaiman Range
PUNJAB
SIND
BALUCHISTAN
GWADAR

PAKISTAN

The Agricultural Importance of Wild Pigs to Sugarcane Production in Faisalabad District

The wild pig (*Sus scrofa*), also known as the wild boar, is a common and serious pest of agriculture throughout most of the irrigated areas of Punjab Province, Pakistan. Wild pigs are particularly destructive to sugarcane when the stalks are ripening and the juice is sweet. They also feed upon maize, watermelon, potato, sweet potato, peas, chilies, clover, wheat, rice, and groundnut.

A field survey of the agricultural importance of wild pigs and the damage they inflict on ripening sugarcane in Faisalabad District was carried out in early December, just before harvest. Eighty-one fields in 24 village areas were randomly selected and examined for wild pig damage; farmers were interviewed at the same time. Wild pig damage was recorded by entering fields and taking damaged stem counts in quadrats in four areas randomly selected within fields. Early damage assessment quadrats were usually taken near field edges because of the danger of wild pigs being encountered in deeper field interiors. Later damage assessment transects were made using a team of three or four persons entering the interior of fields 0.5 ha or larger. These are the places where pigs usually hide during the day. Damage in the 81 fields averaged 5.26%. Forty-nine fields (60.5%) showed physical evidence of wild pig damage; damaged fields were seen in 22 of the 24 village areas. Using the 1982-83 sugarcane production total for Faisalabad of 3,209,000 metric tons, this damage represented a potential yield loss of 178,000 metric tons, worth approximately 45 million Rupees (US $2.85 million) at today's mill price for sugarcane.

Wild pigs were found to constrain sugarcane production in several ways besides the direct damage they inflict on the crop. Farmers are using harder-rind varieties of sugarcane with lesser recoverable sugar content to reduce wild pig damage. They are afraid to enter fields at night to irrigate; they simply open ditches to flood fields, thus, wasting water. Many farmers have given up maize culture because of severe wild pig damage. Questioning farmers at five villages selected at random revealed that injuries to humans occur and that seven persons had been killed by wild pigs during the past 3 years. This could indicate that several hundred people are killed or injured by wild pigs every year just in the irrigated areas of Faisalabad District. Wild pigs seem to be increasing in abundance in the irrigated areas of the province. At present, there is no satisfactory method of control available to farmers wishing to protect their crops from wild pig damage.

Farmers in the Faisalabad District of Pakistan show wild pig damage in maize field (top) and sugarcane field (bottom).

Wild pig damage to sugarcane stalks (top), where the nodal areas are eaten and large pieces of rind are torn loose; maize (center); and peas (bottom) in Faisalabad District, Pakistan.

Wild pigs damage sugarcane by tearing away the rind with their incisors and eating the juicy inner pith. Pig damage differs from rodent damage; large pieces of rind are torn loose, and damage includes the nodes, which are rarely touched by rodents. The damaged stalks usually wither and die. Farmers leave them in the fields because they are useless as animal fodder. Cattle and buffalo will not eat damaged stalks apparently because of the odor of the pigs.

Control methods used by farmers include aldicarb (Temmick^R), a relatively toxic carbamate. After repeated use, the animals show some reluctance to take the baits in the field. Endrin, a highly toxic insecticide available to the farmers in the market, is sometimes used. Fences of thorny limbs from mesquite and acacia are used to keep wild pigs out of sugarcane fields, but are mostly ineffective. Highly illegal electrified fences, wired directly into the local 220- to 240-V network, are sometimes used. Deaths of humans, water buffalo, and donkeys are attributed to electrified fences. Nonlethal electrified fences should be tested as a possible alternative. The use of night guards and dogs is the most common method of crop protection used by sugarcane growers. However, our survey showed that night-guarded fields quite often had damage, especially if the field was larger than 1 ha. The area was too large for one or two men with dogs to patrol.

The estimated damage of 5.26% to sugarcane is a conservative figure because it includes early damage counts from quadrats taken near field peripheries. When we began the team transects throughout the fields, we encountered higher damage estimates, suggesting that about 10% of the overall sugarcane production in Faisalabad District is damaged. Similar degrees of damage are also reported from the sugarcane areas of Lahore, Sialkot, Gujranwala, Shekhupura, Jhang, Toba Tek Singh, and Sahiwal.

Cooperation With National and International Organizations

An important mission of the VPCP will be to seek cooperation with several national organizations and universities, such as the Vertebrate Pest Control Laboratory, Karachi, and the University of Agriculture, Faisalabad.

During 1985, DWRC staff traveled in Asia, the Caribbean, Latin America, Africa, and Europe in conjunction with ongoing field research activities and, at the request of FAO and foreign governments through USAID Missions or USAID Washington, to assess vertebrate pest problems, review, evaluate, and coordinate present and future research programs, and present seminars. 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 497 man-days in the following countries:

Bangladesh	Barbados	Kenya	Italy
Pakistan	Dominican Republic	Rwanda	United Kingdom
Philippines	Haiti		
Syria	Montserrat		
	Uruguay		

Travel dates, persons involved, countries visited, and the purpose of each trip are outlined briefly in Table 13. Detailed information is contained in individual trip reports on file at the International Programs Section, DWRC.

An important function of the International Programs Section is to provide assistance to many countries and international organizations. During 1985, 176 requests from 62 countries were received and answered in addition to 1,520 reprints and reports that were provided to fellow scientists worldwide (Table 14).

Table 13. International travel for technical assistance projects by USAID/USFWS-DWRC personnel during 1985.

Date	Name	Location	Purpose of trip
5-27 Jan	R. L. Bruggers	Rwanda, Kenya	In Rwanda, outline assistance possibilities to USAID/Kigali by DWRC in On-Farm Grain Storage Project. In Kenya, assist in preparing International Conference on the Quelea: Ecology, Management and Policy. Participate in conference.
8-27 Jan	L. A. Fiedler	Bangladesh, United Kingdom	Participate as vertebrate pest management specialist at Integrated Pest Management Training Workshop in Bangladesh. A proposal was submitted on vertebrate pests in sugarcane to the Consortium for International Crop Protection, USA. In London, finalize report on Training Workshop.
8 Jan-28 Feb	M. W. Fall	Bangladesh, Philippines	Plan and present outline for jackal research and management program in Bangladesh. Discuss current cooperative activities with Philippine Government personnel.
9-23 Jan	J. W. De Grazio	Kenya	Participate in International Conference on the Quelea: Ecology, Management and Policy.

Date	Name	Location	Purpose of trip
10-21 Jan	J. O. Keith, R. D. Curnow, R. W. Bullard, R. A. Dolbeer, B. E. Johns	Kenya	Participate in International Conference on the Quelea: Ecology, Management and Policy.
19 Feb-16 Mar	J. W. De Grazio	Uruguay	FAO consultancy to investigate and further define bird damage problems and recommend course of action.
8 Apr-16 May	R. L. Bruggers	Kenya	Prepare for and conduct hazard studies of fenthion and analyze data.
13 Apr-16 May	J. O. Keith, P. A. Hegdal, J. B. Bourassa	Kenya	Conduct hazard study of fenthion used as a roost spray for quelea control.
28 Apr-15 May	G. C. Mitchell	Haiti	Begin studies on effects of plastic flagging to reduce woodpecker damage to maturing corn. Followup on small-farm rodent survey; determine needs and priorities for laboratory and field studies.
7 May-10 Jun	J. E. Brooks	Pakistan	Prepare Scope of Work and Work Plans for the Vertebrate Pest Management Program as part of the Food Security Management Project.
19 May-7 Jun	D. J. Hayes	Haiti	Assist in developing bird control methods. Plan and conduct LD50 and R50 training workshops on bird species.

Date	Name	Location	Purpose of trip
2-30 Jun	L. A. Fiedler	Haiti, Montserrat, Barbados	Haiti: Review and summarize data on small-farm survey of vertebrate pests. Montserrat: Review proposed rodent control project and complete environmental assessment of proposed project. Barbados: Review and modify project paper and environmental assessment.
9 Jun-7 Jul	G. K. LaVoie	Kenya	Assist in studies on On-Farm Grain Storage Project.
2-27 Sep	P. P. Woronecki	Dominican Republic	FAO consultancy with project "Management and Control of Rodents in the Dominican Republic" to determine status of vertebrate pest problems and techniques used to control rodents.
17-28 Nov	G. Clay Mitchell	Syria	Upon request by the Arab Center for Studies of Arid Zones and Dry Lands, review vertebrate pest problems in the Arab League countries.
19 Nov-22 Dec	M. J. Jaeger	Bangladesh	Evaluate field research. Meet with USAID and BARI officials on project status.
25 Nov-5 Dec	R. L. Bruggers	Italy, United Kingdom	In Rome, attend FAO meetings. In Oxford, consult with editors of Oxford University Press.

Table 14. Requests to International Programs Section, DWRC, for assistance during 1985. This table does not include requests to DWRC biologists stationed at Bangladesh and Pakistan field stations.

Type of request or activity	Months												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Information on International Programs	3	1	1	4	2	3	0	1	1	2	2	1	21
Literature or information on research and crop protection methods	12	16	11	4	12	3	6	3	3	10	6	9	95
No. reprints provided	117	150	299	32	33	108	286	169	121	41	44	120	1520
Training/graduate school inquiries	1	0	1	0	1	0	0	0	0	0	1	1	5
Workshops/symposia/conferences	0	1	4	0	0	0	1	0	2	1	0	0	9
Materials/photographs	0	0	0	1	3	0	1	0	2	0	1	0	8
TDY's/visits/project requests	0	1	1	1	2	2	0	0	2	1	1	2	13
Hiring possibilities	0	0	2	0	0	0	1	0	0	0	0	0	3
International visitors to DWRC	0	0	1	0	4	2	9	4	0	2	0	0	22
Funding	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	133	169	320	42	57	118	304	177	131	57	55	133	1696

Originating countries:

Jan Cameroon, Egypt, Indonesia, Israel, Kenya, Malawi, Nigeria, North Quay, Pakistan, Poland, Tanzania, United Kingdom.

Feb Cuba, Greece, India, Kenya, Morocco, New Zealand, Niger, Peru, Rwanda, Scotland, Senegal, Sudan, Switzerland, Tanzania, USA, Zambia.

Mar Argentina, Australia, Bangladesh, Chile, Costa Rica, Italy, Morocco, Niger, South Africa, USA, Uruguay.

Apr Ecuador, Italy, Kenya, Philippines, South Africa, USA, Sweden.

May Argentina, Colombia, Costa Rica, Dominican Republic, Galapagos, Guinea (Conakry), India, Italy, Liberia, Nicaragua, Niger, Nigeria, Philippines, Sri Lanka, Somalia, Syria, Uruguay, West Germany.

Jun Ethiopia, India, Kenya, Pakistan, Peru, United Kingdom, West Germany.

Jul Argentina, Costa Rica, Hong Kong, India, Kenya, Maldives, Pakistan, Philippines, Somalia, Tanzania, Uganda, Uruguay, Western Samoa.

Aug Colombia, Malaysia, Somalia, Uganda, Venda.

Sep Guinea (Conakry), Morocco, Niger, Peru, Philippines, Somalia, USA, Uruguay, Venezuela.

Oct Argentina, Burma, Galapagos, Japan, Kenya, Tanzania, Uruguay, Zimbabwe.

Nov Brazil, Burma, Costa Rica, Indonesia, New Zealand, Poland, Pakistan, Somalia, USA.

Dec Ecuador, Kenya, Panama, Sierra Leone, United Kingdom, USA, Uruguay.

COOPERATIVE RESEARCH

DWRC personnel have established an extensive network of international organizations with whom they cooperate in research areas of mutual interest. Two research studies conducted during 1985 that exemplify the effectiveness of this collaborative effort include evaluating Bird-scaring Reflecting Tape(R) to protect crops from birds and assessing hazards of fenthion sprays in quelea control operations. The bird-scaring tape studies began in 1984 and were continued during 1985 with individuals from USAID-sponsored DWRC staff and U.S. Department of the Interior (USDI)-funded Fish and Wildlife Service in Ohio; Bangladesh Agricultural Research Institute; National Bird Control Unit, Arusha, Tanzania; National Crop Protection Center, Los Baños, Philippines; and All-India Coordinated Research Project on Economic Ornithology, India.

The hazard assessment study was a cooperative effort of UNDP/FAO, the Desert Locust Control Organization for Eastern Africa (DLCO-EA), and DWRC's Branches of Wildlife Damage and Research Support. DWRC provided technical expertise and materials to assess nontarget populations, habitat, and animal exposure using bioassay, analytical, and radiotelemetry techniques. FAO Regional Quelea Project and DLCO-EA provided all logistical support including spraying of the colonies, laboratory facilities, and ground and aerial tracking capabilities.

In addition, the following organizations supported or assisted in the study: Director of Wildlife Conservation, Ministry of Tourism and Wildlife, Kenya; International Laboratory for Research on Animal Diseases (ILRAD); Crop Production Division, Department of Agriculture, Ministry of Agriculture and Livestock Development, Kenya; Agriculture Development Corporation; East African Army Worm Project/DLCO; and USAID/Kenya.

Reflecting Tape Shows Promise for Reducing Bird Damage to Crops Worldwide

Researchers at DWRC and cooperators at the International Programs Field Stations have shown that Bird-scaring Reflecting Tape can reduce bird damage to a variety of crops. Bird-scaring Reflecting Tape is manufactured by several companies in Japan, including Yamani-Sangyoh Co., Ltd., 1-28, Saikudani 1-chome, Ten'nohji-ku, Osaka, JAPAN, and distributed by several others, including Maruzen Trading Co., Ltd., c/o Fuji-Bldg. 39-2, Ueshio-Cho, 2-chome, Minami-Ku, Osaka, JAPAN, and Nishizawa Ltd., Tokyo Branch, 12-5, Kodenmacho Nihonbashi, Chuo-Ku, Tokyo, JAPAN. This tape is an elastic, transparent, synthetic resin to which a silver metal layer

is applied by vapor deposition, then coated with colored synthetic resin--in this case, red; other colors are available. The three-layer tape is 0.025 mm thick, 11 mm wide, and sold in 82- or 100-m rolls by these distributors for US $0.36 and $0.75/roll, respectively. The tape reflects sunlight to produce a flashing effect, and when stretched and twisted, it pulsates and produces a loud, humming, or sometimes thunder-like noise in the wind. In Japan it is called "Boh-choh" or "Tori-oi" tape and is used by farmers to protect rice fields from Java sparrows (Padda oryzivora).

When suspended in parallel rows above plots of ripening crops ≤1.3 ha in size, Bird-scaring Reflecting Tape provided partial to complete protection for between 1 and 3 weeks (when these studies ended) in a variety of bird damage situations in Bangladesh, the Philippines, India, the United States, and several other countries. Despite circumstances unique to each test situation, bird species seemed to respond consistently to tape: three species of crows--large-billed crows (Corvus macrorhynchos), house crows (C. splendens), and common crows (C. brachyrhynchos)--in four different countries fed considerably less (as much as 83% in one study) in taped plots of corn; rose-ringed parakeets (Psittacula krameri) almost completely avoided taped plots of corn (resulting in yields of nearly 300 kg/ha greater than in an untaped plot) and sunflowers (resulting in no additional damage); village weavers (Ploceus cucullatus) and munias (Lonchura spp.), at least in the absence of alternative crops, seemed insensitive to the tape when installed over sorghum at ≥5-m intervals; and red-winged blackbirds (Agelaius phoeniceus) seemed to begin habituating to the tape in large corn fields sometime after 3 days, when provided an unprotected entry point to the field. Red-winged blackbirds did, however, seem to avoid taped millet fields, with damage increasing only 4% from preinstallation tests in taped plots compared to between 39-43% in untaped plots.

From more subjective accounts in four 25-m^2 home garden plots, the tape has protected tomatoes from speckled mousebirds (Colius striatus) in Nairobi, Kenya; corn from house crows in Kathmandu, Nepal; and strawberries and raspberries from American robins (Turdus migratorius) and Brewer's blackbirds (Euphagus cyanocephalus), respectively, in Denver, Colorado. It also seemed to repel common crows from roosting on and pecking holes in a building roof in Columbus, Ohio.

These results were further substantiated by an extensive followup study of this material in the United States. The bird-repellent effectiveness and cost of Bird-scaring Reflecting Tape strung across agricultural fields in parallel strands at intervals of 3, 5, and 7 m was evaluated in Ohio. Tapes at 3- and 7-m intervals

reduced ($P < 0.05$) the number of blackbirds (brown-headed cowbirds, *Molothrus ater*, and red-winged blackbirds) feeding in proso millet fields, and the percent of panicles damaged by birds compared with untaped fields. Damage by blackbirds to sweet corn was similarly reduced in 3- and 7-m interval taped fields, but the tapes did not reduce deer (*Odocoleus virginianus*) damage. Blackbird numbers and damage were reduced in sunflower fields with 5-m interval tapes; however, American goldfinches (*Carduelis tristis*) and mourning doves (*Zenaida macroura*) appeared unaffected by the tapes. The estimated cost of deploying the tapes in these studies in the United States was $22.50-48.53/ha.

Numerous other pest situations exist where, with imaginative installation techniques, this tape also might be useful. This tape seems to provide a simple, inexpensive, and safe technique for protecting small crop fields in both the U.S. and developing countries. It might even be more effective if used in conjunction with other management techniques.

Hazards of Fenthion Sprays to Nontarget Birds During Quelea Control Operations in Kenya

The effect of applying fenthion to two quelea nesting colonies on quelea and nontarget birds was evaluated in Kenya. Spraying fenthion on nesting quelea is the most frequently used method in Africa to kill quelea to protect crops. However, the potential hazards to nontarget wildlife of spraying fenthion had not been assessed before this study. The study was intended to determine the degree of fenthion contamination in the environment and the exposure and mortality of nontarget bird species resulting from quelea control operations. This included birds in the spray area and others such as raptors that are attracted by dead and dying quelea.

Two nesting colonies, 10 and 40 ha in size, were studied on the Kulalu Ranch, just outside of Tsavo East National Park, Kenya. Both colonies were in the fledgling stage when sprayed. The following information was obtained:

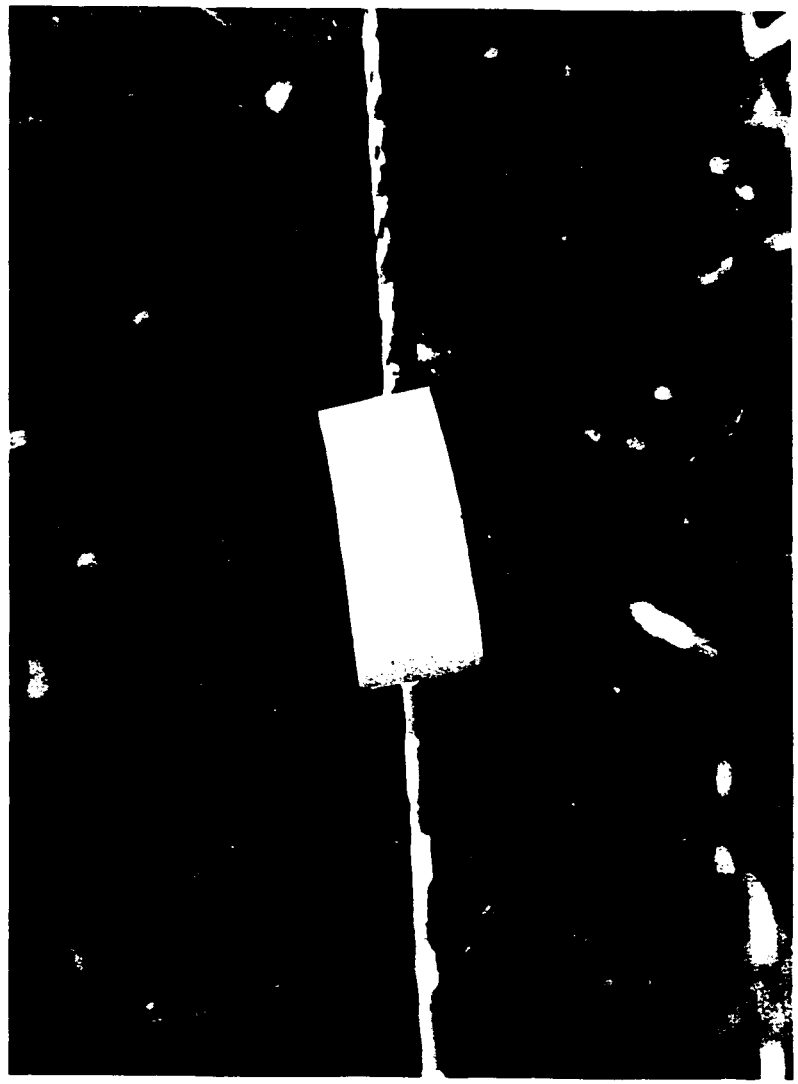
Size and density of colonies.

Droplet size and drift during each spray operation.

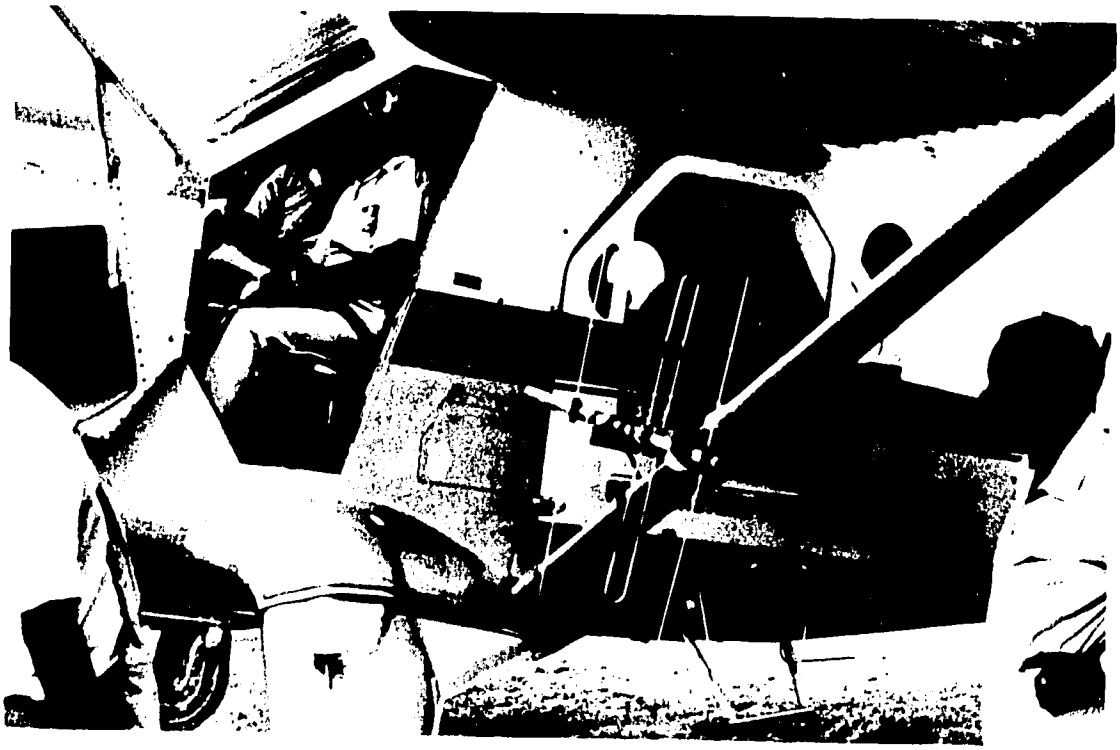
Identification of birds inside and outside of each colony before and after each spray operation.

Pre- and postspray cholinesterase levels (an indication of fenthion exposure) in several raptors and many insectivorous and granivorous birds.

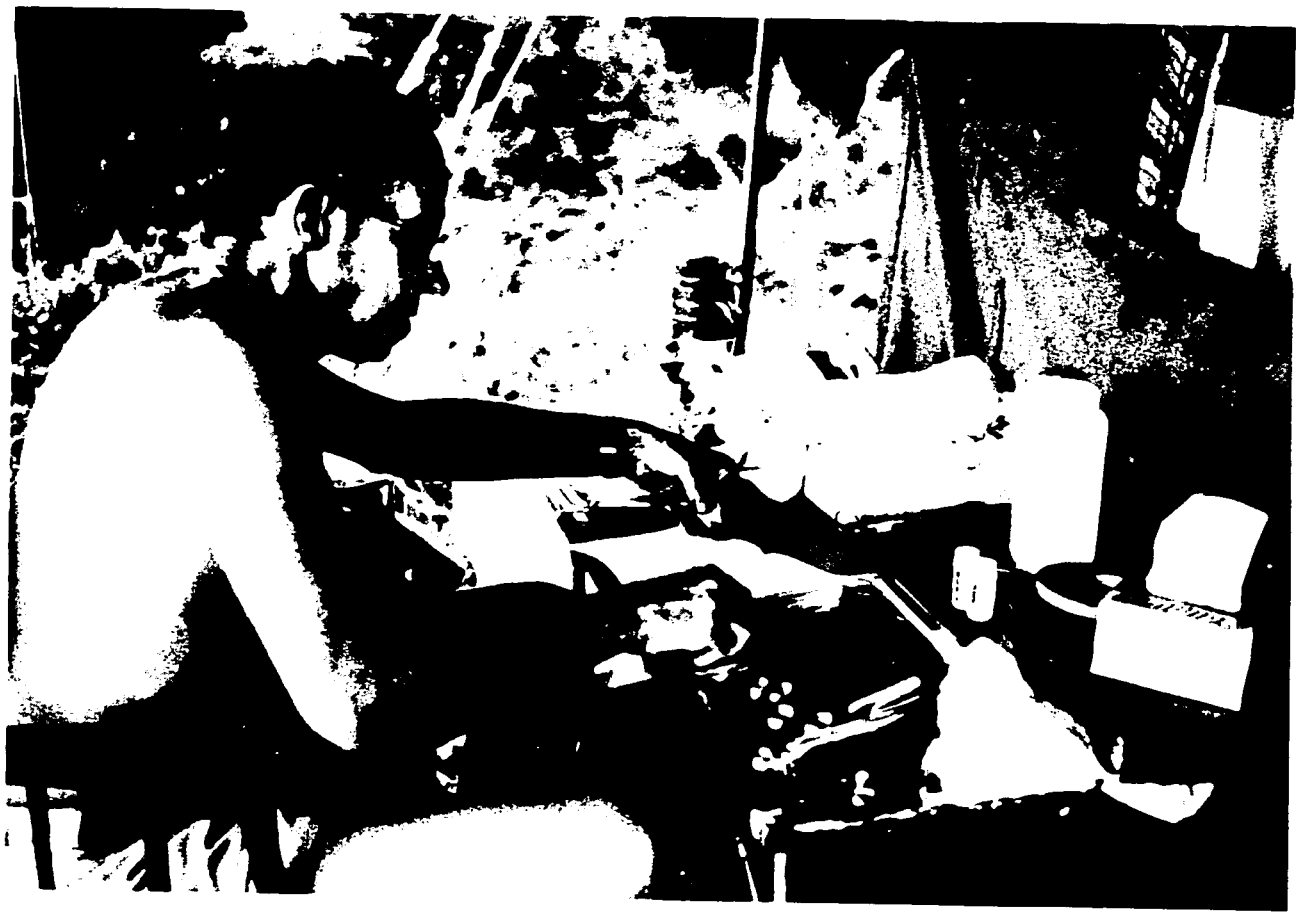
Snares and traps were prepared to capture raptors and mammalian predators.



Droplet papers were placed in and around the colonies to determine the spray pattern.



Blood samples were removed from captured animals, then they were equipped with radio transmitter, released, and tracked by aircraft.



Blood samples were prepared in the field and later analyzed for cholinesterase levels to determine exposure to fenthion.

Dispersal pattern of sprayed quelea.

Movement patterns of radio-equipped raptors, doves, and quelea before and after each spray operation.

Spray effect on insects.

Predation rates on dead quelea in the colonies before and after spray operations.

Small mammal (rodent) activity inside and outside of the colonies before spray operations.

Fenthion residues from dead and dying quelea and from grass inside the colonies over a 4-day postspray period.

Because data from this study have not yet been analyzed or completely interpreted, only general conclusions can be outlined. A detailed report is being prepared.

The nesting colonies, 10 and 40 ha in size, were sprayed with 24 L and 100 L fenthion, respectively, from a fixed-wing aircraft using Micronair spray system set to give 80 μ volume median diameter (vmd) droplets. In both colonies, quelea died during a 4- to 5-day time period, and in one colony dead and dying birds were found over an area of at least 25 km^2. Depressed cholinesterase levels in the blood of raptors trapped in the area indicated that dying quelea in and around colonies affected raptors that fed on them. A similar situation was found with several species of insectivorous birds that fed on dead and dying insects in the colonies after the spray. Additional investigations in different situations and improved application techniques in quelea control operations are needed before general recommendations can be made.

International Conference on the Quelea: Ecology, Management, and Policy; Taita Hills Lodge, Kenya

The quelea is undoubtedly the world's most severe avian pest to agriculture, being responsible for millions of dollars of damage in two-thirds of the African countries. DWRC has provided technical assistance to developing countries and international organizations that are affected by this pest problem since the early 1970's.

This conference, the first since 1957 when the quelea problem gained international attention, was designed to bring together the world's foremost experts in quelea biology and control. Despite the international concern with quelea problems, only a few scientists have been intensively involved in quelea research.

The conference was organized by DLCO-EA in collaboration with FAO. Eighty participants representing 25 countries (Africa--17, Europe--7, and USA) and 18 international organizations, including DWRC, attended the conference. Seventeen technical sessions were held during the 5-day conference followed by 2 additional days of policy sessions. DWRC personnel presented six technical papers, one policy paper, and chaired two technical session. Papers presented by DWRC personnel covered recent advances in radiotelemetry, mass-marking, feather trace-element analysis, chemical repellents, and less susceptible sorghum varieties.

Summaries of papers presented by these individuals will be published in a proceedings and will form the basis of a book "Ecology and Management of the Red-billed Quelea" being coedited by Drs. R. L. Bruggers, DWRC, and C.H.H. Elliott, FAO, to be published by Oxford University Press, Oxford, United Kingdom. This book will bring together much of the research, management, and training aspects of quelea work conducted during the past 20 years. Nearly all chapters are drafted or have been reviewed. This book will compile the accumulated knowledge on this pest species.

PROBLEM DEFINITION

Rwanda

At the request of the project manager of the Crop Storage and Marketing Research Project (USAID 696-0107) through USAID/Rwanda, this country was visited by DWRC staff to determine if vertebrate pests might pose a problem in postharvest on-farm storage structures and in preharvest ripening cereal crops. This was the first visit to Rwanda by a DWRC scientist.

Agriculture: Rwanda is a poor, over-populated country with a subsistence economy. Its size is 26,338 km^2 or about as large as Maryland, with a population of 5.5 million. It is primarily a French-speaking country that came under Belgian influence until independence in 1962. Although Rwanda has one of the highest population growth rates in the world (3.7%) and is the most densely populated country in Africa, agricultural production has kept ahead of population growth over the past 10 years. Agriculture, primarily coffee, tea, and pyrethrum, accounts for 46% of its gross national product. Rwanda is extremely mountainous, with only 48% of its land arable, of which 90% is cultivated. Individual subsistent farmers usually cultivate less than 1 ha. The average per capita income is US $250 annually. The country's literacy rate is 37%, and life expectancy is 45.2 years.

Postharvest Storage: Efforts are being made to increase agricultural yields and to emphasize production of highly nutritional crops. The present selection of crops (in order of the percent land devoted to them) includes beans, bananas, sorghum, tubers, and maize. The purpose of the USAID Crop Storage and Marketing Research Project is to support research on storage and marketing of beans and sorghum in Rwanda. A principal objective of the project is to determine the extent of storage losses at various levels in the food grain supply system (farm, community, and national), as well as the relative importance of the factors causing those losses and to develop, test, and demonstrate technologies at the appropriate levels, which will reduce losses. Preliminary information collected by project staff has indicated that rodents may be important pests in both home and warehouse storage structures.

Most on-farm storage is in woven baskets, lined with cow dung, that are placed inside the home near the cooking area. In some homes, farmers cover stored beans and sorghum with 20-30 cm of ash to prevent rodent access. All farmers at the four farms visited either had damage to stored sorghum or reported regular rodent damage to stored beans. Farmers also reported rat damage to potatoes and bananas. Rodentox (coumarin) seems to be locally available and is occasionally used.

There is a need to determine the impact of vertebrate pests (primarily rodents) on stored grain in various storage and drying structures. Information needed in this project includes: survey of relevant literature on rodent/storage problems; identification of rodent pests; estimation of in-storage losses; evaluation of contamination; determination of rodent food habits; demonstration of rodenticides; and organization of training programs.

Preharvest Pest Problems: Village weavers (*Ploceus cucullatus*) damage maize throughout the country, including at research stations such as the Institute des Science Agronomique du Rwanda (ISAR) at Rubona. Red-billed quelea (*Quelea quelea*), bishops (*Euplectes* spp.), and sparrows (*Passer* spp.) damage rice fields at the Kabuye Rice Project near Kigali, and ducks are apparently an important pest at certain times of the year when the rice is sown or transplanted. Field trials on ripening sorghum at the ISAR station at Rwercre are disrupted by bird damage. In other areas of the country, crows (*Corvus* spp.) reportedly damage peanuts, pigeons (*Columba* spp.) damage soybeans, and weavers damage sorghum and maize. Techniques to prevent bird damage to newly sown rice and to ripening crops at research stations are available and could be immediately implemented.

Rodent Activity in Agricultural Areas on Small Farms in Haiti

Nine typical Haitian farms with a mixed-cropping system at Croix-des-Bouquets, in the Cul-de-Sac Plain were selected to monitor rodent activity from June 1984 through November 1984 (Table 15). The vertebrate pest staff of the Ministry of Agriculture at Damien were assisted in selecting the study sites, mapping farms, using tracking tiles and snap-traps, and collecting initial data. Rodent activity on all farms was assessed with tracking tiles (1 per 100 m^2) and on three farms with snap-traps (about 1 per 100 m^2), each set for 2 nights/month. To evaluate reduced rodent populations, three farms were snap-trapped monthly, three were baited monthly with a rodenticide, while three served as reference. Crops present were monitored each month. Data from the three snap-trapped farms were collected through January 1985.

Table 15. Survey of farms with a variety of crops present between June 1984 and January 1985; Cul-de-Sac Plain, Haiti.[a]

Land use within each farm	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Soil preparation	1	1	1	0	0	2	2	0
Fallow	6	6	4	2	2	1	1	0
Corn	7	4	1	1	1	1	1	0
Manioc	4	4	4	4	4	2	1	0
Sweet potato	5	5	6	6	6	4	1	0
Sugarcane	6	7	7	7	7	4	2	1
Plantain	4	4	4	4	4	1	2	1
Sorghum	2	2	4	4	4	2	0	0
Squash	2	2	1	1	1	0	0	0
Beans	3	1	1	1	1	1	1	2
Chive	1	1	1	1	1	1	2	0
Spinach	0	0	1	1	1	1	0	0

[a]Number of farms surveyed: Jun--9; Jul--9; Aug--9; Sep--9; Oct--9; Nov--5; Dec--3; Jan--2.

Mean farm size was 4,664 m^2 and included three to five crops mixed with fallow or land preparation areas. Corn, manioc, sweet potato, sugarcane, plantain, sorghum, and several vegetables were typical crops. Corn was harvested in June and July, the beginning of the wet season. Rat activity determined from tracking tiles and snap-trap success increased from a July low to a November peak (Fig. 3). Of 10 major crops grown, areas containing maturing

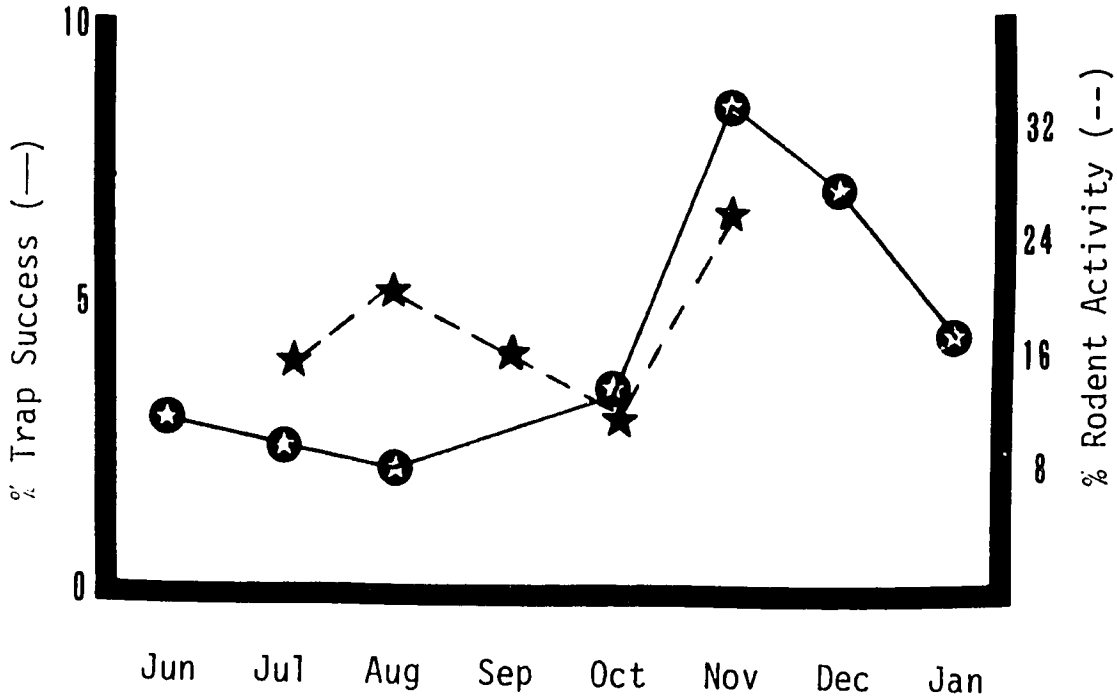


Fig. 3. Snap-trap success (%) (n = 3) and rodent activity (%) (n = 3) on six farms from June 1984 to January 1985, Cul-de-Sac Plain, Haiti.

sugarcane, sweet potato, and manioc had higher rat activity indices and more rats were trapped. Rat activity was not reduced by monthly snap-trapping conducted on three farms, while activity declined on the three baited farms from July through October.

This study indicated that snap-trapping 2 nights/month with 1 trap/100 m^2 was not sufficient to reduce rodent activity; however, rodenticide baiting (once or twice per month) with 100 g (0.025% anticoagulant in rice) in each bait holder (1 per 1,000 m^2) did reduce rat activity. Thus, baiting initiated in July/August, concentrated in and around more susceptible crops such as sugarcane, manioc, and sweet potato, should be emphasized. Also, a study should be conducted to monitor rodent activity and cropping systems during the dry season (January through June), when corn and other susceptible crops are present.

Rodent Problems on Montserrat, West Indies

Montserrat, a small Caribbean island country in the Lesser Antilles was visited in June 1985 at the request of the Regional Development Office/Caribbean, USAID/Barbados, to assess the nature of rodent problems. Urban and rural village sites with potential rodent problems and several farms were visited. Background information was obtained from agricultural and health specialists in Plymouth, Montserrat.

There are more than 500 farmers on the island, but only 136 key farmers, who provide about 80% of the total production on 95.5 ha. Primary crops grown on private farms or on leased government land include peanuts, sweet potato, and several vegetables. Livestock production, which received increased attention when sugarcane was phased out about 10 years ago, is also prominent. Most farms are small, averaging 0.4-0.8 ha with about 50% of the area producing a variety of crops.

All urban and agricultural areas on Montserrat are affected by rodent pests. During our visit, two commensal rodent species were trapped. *Rattus norvegicus* was present in urban and rural structures, while *R. rattus* was found in agricultural fields. *Mus musculus* may have been present, but was not caught in the large traps used. For several years, farmers have complained about field crop losses due to rodents. Government estimates of damage determined from farmer interviews were at least 30% of potential field harvest of peanuts, sweet potato, and corn. Several other crops are affected, including maturing mangos, pineapples, and oranges. In some cases, farmers have elected not to grow susceptible crops, such as peanuts, because the risk of rodent damage is too great. Usually, a rapid transfer of field crops to market requires little on-farm storage; however, when crops are stored, rodent losses are high.

In May 1983, the first human case of leptospirosis, a bacterial infection transmitted to humans through rodent urine, was diagnosed in a Montserratian sent to Barbados for treatment. Several pigs and goats near the affected person's residence carried antibodies for leptospirosis. This incidence increased public concern for urban rodent control.

The purpose of the proposed rodent control project is to reduce pre- and postharvest food losses as well as the risk of rodent-transmitted diseases. Farmers would be the main beneficiaries through reduced crop losses, but the entire populace would benefit if importation of foods (currently 60%) could be reduced, and export quotas for peanuts would increase. A large export market for peanuts exists that current production cannot satisfy.

The potential contribution of selected agricultural crops to economic growth is high if rodent damage can be controlled. An almost unlimited export market for peanuts exists, but it cannot be supplied with current hectarage and harvests. Increased hectarage and yields would generate increased farm labor employment because peanuts are a labor-intensive crop. Tapping the export potential of this crop would benefit the entire island through improved trade balances. Sweet potato and mango, two crops that are exported to Caribbean countries, are significantly damaged by rodents, and increased production through decreased rodent losses may contribute to maintain or increase these markets.

In the past, efforts to increase food production have been very successful. The number of primary farmers has risen dramatically and fallow agricultural land has been put back into production. However, this activity has contributed to the rodent problem, since newly opened farm areas tend to be more susceptible to rat infestation. The combination of uncultivated areas adjacent to cultivated, susceptible crops offering abundant food and shelter, provides an ideal environment for field rodents.

Increasing agricultural production of the most susceptible crops such as peanuts, sweet potato, and corn has been somewhat limited by the risks imposed by rodent pests. Because of costly inputs required for growing peanuts, many farmers have either stopped growing them or have reduced the hectarage because of previous losses due to rodents. Other crops, such as sweet potato, that have been subjected to severe rodent damage, continue to be grown since they require less expensive inputs, hence, less risk.

Feral Cat Predation on Nesting Seabird Colony in the Galapagos Islands, Ecuador

Between 1982 and 1984, the dark-rumped petrel (*Pterodroma phaeopygia phaeopygia*) nesting colony on Isla Floreana made a remarkable comeback after a rat control project was initiated. Annual nesting success increased from about 30% in 1982 to over 70% in 1984. However, in 1985, nesting success declined to about 30%. The cause of this decline was not due to rodents (their population remained at very low levels), but primarily to feral cats.

More than 40 adult birds, in addition to a number of nestlings, were lost due to feral cat predation. The increased predation by cats has threatened the endangered seabird colony, and efforts to control cats by shooting and trapping were initiated on Isla Floreana. Other methods such as toxic baiting are being explored

A young dark-rumped petrel (Pterodroma phaeopygia).

to reduce the problem which may prove to be more difficult to solve than that of rodent predation. This situation illustrates the need for comprehensive management approaches rather than simple control of perceived problem species.

Evaluation of Rat Damage and Control Methods in Coconuts in the Philippines

(Abstract from Ph.D. Thesis, Paciencia Milan. Technical assistance was provided by DWRC project personnel at the National Crop Protection Center, Los Baños, Philippines.)

Rat damage and control in coconuts were evaluated in Leyte, Philippines, for 16 months. Of the rodent species caught in the study area, the Philippine ricefield rat (*Rattus rattus mindanensis*) and the Polynesian rat (*Rattus exulans*) were the most serious pests of coconuts. Both were caught in tree crowns and on the ground. Tracking tiles gave a less variable index of the rodent population than using results from removal trapping.

Rat damage was concentrated on the basal portion of nuts, and medium to large-sized nuts (30 to >50 cm in circumference) sustained the highest damage. Nut damage was highly correlated with increased rodent activity and trap success, including movement of rats into the coconut area following land use changes. Movements were monitored by using metallic flakes incorporated with nontoxic baits that subsequently were detected in rat feces and the gut of trapped rats.

Laboratory tests on bait acceptance and bait container preference indicated high acceptance of broken rice and coconut as bait and coconut husks as bait containers. These findings were utilized in placing poison bait in the field.

Five control methods were evaluated in this study: crown trapping, ground trapping, ground baiting, trunk baiting, and crown baiting. Victor 4-Way snap-traps were used in trapping, and an anticoagulant rodenticide, 0.025% Ratoxin (warfarin), was placed in baiting trials. Crown baiting 10% of the coconut palms provided the most effective control of the techniques evaluated, exhibiting 104.8% increase in yield, 76.6% reduction in rat damage, and 88.5% reduction in rat activity. With a damage threshold level of 5 nuts/tree/year, the current cost of control, and market value of copra, this technique was the most cost-effective, aside from being the most target-specific.

A management strategy was formulated based on knowledge of the pest species, abundance, movement, extent and nature of nut damage, and the performance of the control methods evaluated. The selection of appropriate and effective control measures also necessitates the understanding of the agronomy of the coconut and its intercrop to be able to time application of control properly for maximum efficacy.

Vertebrate Pest Problems in Syria and Jordan

The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) requested through USAID/Washington that a DWRC biologist review vertebrate pest problems in Syria and Jordan. ACSAD is a function of the Arab League and is funded by 16 Arab nations. The main objective of ACSAD is to develop regional research programs and field studies in arid zones that include animal and plant production. The review was conducted in late November before winter planting; therefore, there was no opportunity to observe maturing cereal crop fields or producing fruit trees.

The major rodent species cause damage to agriculture in these countries. The levant vole (*Microtus guentheri*) attacks cereal crops, stored wheat, and seed potatoes. A jird or gerbil (*Meriones tristrami*) is a minor agricultural pest causing damage in wheat fields and grazing ranges. The mole rat (*Spalax leucodon*) causes severe damage in ACSAD experimental fields and to fruit trees. No publications on pest birds in agriculture in Syria or Jordan were found during a literature search.

ACSAD has developed four varieties each of wheat and barley that are drought-resistant, disease-resistant, and excellent producers. Vertebrate pest damage to experimental plots has been a problem in the testing of these varieties.

The Director General of ACSAD has asked the DWRC to assist in developing a vertebrate pest control component for their Center. Necessary activities would include identification and distribution of pest species, damage assessment techniques for wheat and barley, reproductive and ecological studies of pest species, and training.

Postharvest Stored Food Losses at the Farm and Village Level in Bangladesh

As part of a larger project to assess food storage losses from all causes in Bangladesh, a study on postharvest losses due to vertebratè pests at the farm and village level was conducted between July 1984 and June 1985. This study was a cooperative undertaking of DWRC/USAID VPCL in Joydebpur, FAO, and BRRI. Survey results based on rodent population indices obtained from inked tracking tiles and snap-traps indicated that the average farm family in deepwater rice-growing areas suffers a potential annual loss of 50 kg of paddy due to rats and mice. Extrapolating these results to the 13 million farm families in Bangladesh indicates a potential loss of approximately 600,000 metric tons or US $110 million of paddy annually. This represents about 5% of the annual production of rice in Bangladesh.

The study was conducted in a deepwater rice-growing area in Mirzapur Upazila, Tangail District. At the time the study was initiated June 1984, the area was already flooded from the early onset of the monsoon rains a month before. The villages are built on raised mounds of earth, standing about 3-5 m above the surrounding fields, and these become seasonal islands during the monsoon rains. The island villages are accessible by boat during the flood periods. A total of 240 farm households was sampled. In 8,112 trapnights, 563 small mammals [(409 house mice (*Mus musculus*), 42 lesser bandicoot rats (*Bandicota bengalensis*), 31 roof rats (*Rattus rattus*), and 81 house shrews (*Suncus murinus*)] were captured (Table 16). The annual population in these structures, estimated from activity indices by placing inked tracking tiles in the houses before and after removal trapping, was 2,107 small mammals (an average of 176 per month; Table 17). Since the average number of rodents was 7.52 per structure, and the average farm family had 1.55 structures, the estimated rodent population per farm family was 11.65 rodents. Based on laboratory tests of the food consumption of each species, these rodents can cause a potential loss of 50 kg of stored paddy/year/farm family.

Small-mammal activity occurred mainly above the floor in the upper parts of houses, due to the climbing activities of house mice and roof rats. House shrews were most active on the floor (Table 18). Table 19 summarizes tracking tile data. Data obtained from both

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trapping animals and measuring rodent activity with tracking tiles indicate that 65-70% of the small-mammal activity in farm households takes place off the floor and during the night.

Table 16. Animal species and numbers captured in farmers' houses, Mirzapur Upazila, Tangail District, Bangladesh, 1984-85.

Month	Species				Total
	M. musculus	*R. rattus*	*B. bengalensis*	*S. murinus*	
Jul	30	4	0	5	39
Aug	27	0	6	12	45
Sep	53	1	19	4	77
Oct	55	2	0	15	72
Nov	44	5	8	5	62
Dec	62	6	3	9	80
Jan	50	4	0	11	65
Feb	14	1	1	3	19
Mar	24	0	0	0	24
Apr	11	3	0	4	18
May	12	0	0	5	17
Jun	27	5	5	8	45
Total	409	31	42	81	563
% of total	72.6	5.5	7.5	14.4	

Table 17. Tracking tile activity, number of animals captured, and estimated small-mammal populations, Mirzapur Upazila, Tangail District, Bangladesh, 1984-85.

Month	% positive tile activity		Animals removed	Estimated original population
	Pretrapping	Posttrapping		
Jul	41.2	18.6	39	71
Aug	47.2	28.3	45	112
Sep	56.0	48.2	77	553
Oct	55.1	39.2	72	249
Nov	36.9	26.7	62	224
Dec	34.8	27.0	80	357
Jan	24.4	14.6	65	162
Feb	20.6	9.4	19	35
Mar	21.2	13.8	24	69
Apr	26.9	18.8	18	60
May	29.4	15.0	17	35
Jun	26.2	19.6	45	180
Total			563	2,107
Mean	35.3	23.5		

Table 18. Animal species by place of capture within farmers' houses houses, Mirzapur Upazila, Tangail District, Bangladesh, 1984-85.

Location	Species				Total
	M. musculus	*R. rattus*	*B. bengalensis*	*S. murinus*	
Baskets	82	6	5	0	93
Platforms	260	23	12	8	303
Floor	67	2	25	73	167
Total	409	31	42	81	563

Table 19. Tracking tile activity by location in houses, Mirzapur Upazila, Tangail District, Bangladesh, 1984-85.

Location	No. tracking tiles	Positive tiles No.	Positive tiles %
Baskets	468	164	35.0
Platforms	584	296	50.7
Floor	960	239	24.9

Animal populations were at peak abundance in September through January, least in February through May, and of moderate abundance in June through August. The quantities of stored paddy fluctuated markedly during the year, with a peak of grain in August and September, and no grain in storage in March and April. Some of this sharp fluctuation was due to adverse and premature flooding during the monsoon season of 1984. House mice were found to have two breeding peaks per year correlated with grain storage peaks.

On-farm Grain Storage Project, Maseno, Kenya

A DWRC biologist visited the On-Farm Grain Storage Project upon request of USAID/Kenya to survey the project area, determine the distribution of pest species, and evaluate the rodent problem to stored grain. The traditional on-farm grain storage structure in Western and Nyanza Provinces is a large, woven basket. Basket fibers vary with local availability. The baskets are about 1.5 m in dia, 2 m high, and have a capacity of approximately 1 ton of cobbed maize. Baskets are set on a low platform about 25 cm above ground. The base of the basket is frequently plastered with cow dung on both sides to a height of about 1 m. Farmers claim the dung prevents rats from climbing the basket. Other storage structures such as wooden sheds, about 3 x 3.5 m and about 2 m high with tin or grass roofs, are not uncommon. Square cribs, made of locally available woods and having about the same capacity and much the same foundation and cover as the traditional basket granary, are also in use on some farms.

Three sites in the Busia, Ikolomani, and Asembo Bay areas were inspected. Busia and Ikolomani areas of Western Province are in the Upper Midland Agroecological Zone with an annual mean temperature of 18-21°C. Ikolomani is about 1500 m above sea level. The

annual rainfall is 1,800-2,000 mm; predominant crops are maize, sorghum, tea, and coffee. The Asembo Bay area is in the Lower Midland Agroecological Zone and is about 1200 m above sea level. The annual rainfall is 1,000-1,200 mm; predominant crops are maize, sorghum, and some cotton.

Unfortunately, there was no maize left in storage structures at any of the sites visited in the Busia area or, in fact, anywhere in Western Province. Under normal conditions, there would be maize stores from the preceding year's harvest; however, they were depleted earlier than usual because of drought conditions during the previous 2-3 years. Some maize stores were found in Ikolomani on farms participating in the Project's "modified versus traditional" storage structure experiment. The storage structures consisted of two storage sheds and one crib with a grass roof. Maize was also stored in sacks in several houses. Rodents in these areas were trapped in houses and storage areas with McGill traps baited with raw beef. Species trapped were *Praomys natalensis* (Smith, 1834) and *Rattus rattus* (Berkenhout). The percentage of active trapping sites or structures by location was 75% at Ikolomani and 100% at Asembo Bay. Losses and contamination seem to be important, but will require development of control techniques before they can be quantified.

Surveys in Food Storage Facilities in Pakistan

Preliminary surveys were begun in food storage facilities in Punjab Province. A stratified random sample of 55 storage sites was selected and visited to physically inspect the premises for vertebrate pest infestations and to interview staff on management and maintenance procedures, loss assessment methods, and control practices. A literature review of food storage problems and vertebrate pest control methods in food storage facilities is being prepared for computer storage.

Laboratory Test on Contamination and Consumption of Stored Wheat by a Closed Population of House Mice, Denver Wildlife Research Center

Rodents contaminate and consume vast quantities of stored grain throughout the world. Unfortunately, most available data on loss assessments are largely undocumented estimates and invalid extrapolations. Precise loss statistics for storage units are essential to determine cost:benefit ratios for control programs and evaluate the development and application of damage control methods. This laboratory study was undertaken as a first step in developing a loss assessment technique to be used in storage units.

Deteriorating food storage facilities are the most common problem leading to vertebrate pest infestations in Pakistan. Mr. Ejaz Ahmad is searching for rodent burrows.

Interviews with management staff at provincial grain storage facilities are part of a vertebrate pest survey in Pakistan.

Our study consisted of a simulation of bulk storage of winter wheat infested with a closed population of house mice (Mus musculus) and was conducted over a period of 150 days in facilities at DWRC. Twelve house mice (eight females, four males) were introduced at the initiation of the study; the number of animals remained fairly constant throughout the study period. A wooden frame with a surface area of 1.97 m^2 was filled with 109 kg of winter wheat to a depth of 6.4 cm to simulate bulk storage. Water was offered ad libitum. Sufficient harborage, bedding, and nesting materials were placed around the perimeter of the room to meet the needs of a growing mouse population.

The mouse population consumed an average of 35 g/day. A total of 5.584 kg of wheat was removed from the storage container during the study period. Approximately 340 g of whole, broken, or kibbled grain mixed with droppings were scattered over the cement floor surrounding the storage container. From our samples of surface wheat (upper 2.5 cm) we could extrapolate 434 droppings and 1,204 hairs per kilogram of grain. A previously developed method for the analysis of urea was used to determine the presence of urine on the wheat seeds. During the 150 days, 65% of the surface seeds and 55% of all seeds were contaminated with urine.

A simulated wheat storage structure at the Denver Wildlife Research Center was filled with wheat, and contamination and consumption by house mice was measured.

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*Mr. Brooks changed assignments from Bangladesh to Pakistan during 1985.

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Paul A. Hegdal	Wildlife Biologist
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[1]Fully funded under a Participating Agency Service Agreement (PASA).
[2]Personnel not funded under a PASA but who participated in work associated with or pertinent to this project.
[3]Foreign nationals associated with the project and funded by their respective governments.

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Date	Name	Representing
13-19 Jan	Mr. Pierre Douville de Franssu	Association de Coordination Technique Agricole, La Rouche-Sur Yon Cedex, France
14 Jan-13 Feb	Dr. Win Kyi	Department of Health, Rangoon, Burma
18-22 Apr	Mr. Wolfgang Meinzingen	FAO, Ethiopia
20 May	Mrs. Aurora A. Hettel	National Crop Protection Center, Philippines
24 Jun	Dr. Ghanshyam C. Chaturvedi	Rodent Centre, Sidhpur, India
24 Jun-12 Jul	Dr. Luko Hilje	National University, Heredia, Costa Rica
15-17 Jul	Mr. Mark J. Bonin	Samoan German Crop Protection Project, Western Samoa
16 Jul	Mr. Chan Moon Lvung	Hong Kong (Trainee at Centers for Disease Control, Fort Collins, Colorado)
17 Jul-31 Jul	Mr. Thadeus C. Tarimo	Tanzania (Student at Bowling Green State University, Bowling Green, Ohio)
24 Jul-8 Aug	Mr. Herbert Okurut-Akol	Serere Research Station, Soroti, Uganda
26 Jul	Mr. Eric S. Albone	Clifton College, Bristol, United Kingdom
27 Jul-15 Aug	Mr. Abdul Kadir Farah Nur	Ministry of Agriculture, Plant Protection and Locust, Somalia

International Visitors (cont'd)

Date	Name	Representing
29 Jul	Mr. Richard Kituyi	Ministry of Agriculture, Kisumu, Kenya
29 Jul	Mr. Kepha M. Mogoi	Ministry of Agriculture and Livestock Development, Nairobi, Kenya
8 Aug	Mr. A. Azeez Hakeem	Ministry of Agriculture, Republic of the Maldives
8-12 Aug	Dr. Melanda Hoque	National Crop Protection Center, Philippines
23 Aug	Lam Yuet Ming	MARDI, Malaysia
1-14 Sep	Mr. Zeinelabdin, M. H.	Sudan (Student at University of California, Davis, California)
1 Oct	Ms. Maria Isabel DiMare Mr. Danilo Valencia	Nicaragua Colombia (Students at Colorado State University, Fort Collins, Colorado)
22 Oct	Mr. K. Hashimoto	Nishizawa Co., Los Angeles, California
22 Oct	Mr. S. Mori	Nishizawa Co., Tokyo, Japan

Short-term Training at the Denver Wildlife Research Center

Several international visitors received short-term training in their field of expertise or any additional training they requested.

Dr. Win Kyi, Department of Health, Rangoon, Burma, is a physician working on communicable diseases. Rodent control work is part of a program that is trying to reduce the incidence of plague in Burma. During his stay in Denver he learned more about rodent control methods. Funding was provided by World Health Organization (WHO).

Dr. Luko Hilje, National University, Herida, Costa Rica, spent 3 weeks at the DWRC collecting information (reprints, photogrpahic materials, methodology) on vertebrate pests. These materials will be used in a new course on vertebrate pest control that Dr. Hilje will teach at National University. Funding was provided by the National University.

Mr. Thadeus Tarimo, National Bird Control Unit, Arusha, Tanzania, recently finished 4 years of formal training in the United States. He spent 2 weeks at the DWRC to learn of recent developments in bird research and technology before returning to Tanzania to work on bird control. Funds were provided by UNDP/FAO.

Mr. Herbert Okurut-Akol has recently been assigned Head of Vertebrate Pest Unit, Soroti, Uganda. In his country, birds are the major pest species. He spent time with Bird Damage Control personnel at DWRC and conducted field studies with personnel at the Sandusky, Ohio, field station. Funding was provided by USAID through Ohio State University, Columbus, Ohio.

Mr. Abdul Kadir Farah Nur, Plant Protection and Locust Control, Ministry of Agriculture, Mogadiscio, Somalia, spent several weeks at the DWRC and received pest bird and rodent management training. Training consisted of participation in laboratory and field research studies, review and collection of essential literature, and individual consultations with DWRC scientists on specialized aspects of bird and rodent control. Funding was provided by USAID through the University of Wyoming, Laramie, Wyoming.

Ahmad, S., E. Haque, H. Mollah, and R. Pandit. Attended Integrated Pest Management Training Workshop, Consortium for International Crop Protection; Joydebpur, Bangladesh; 13-16 January 1985.

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

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