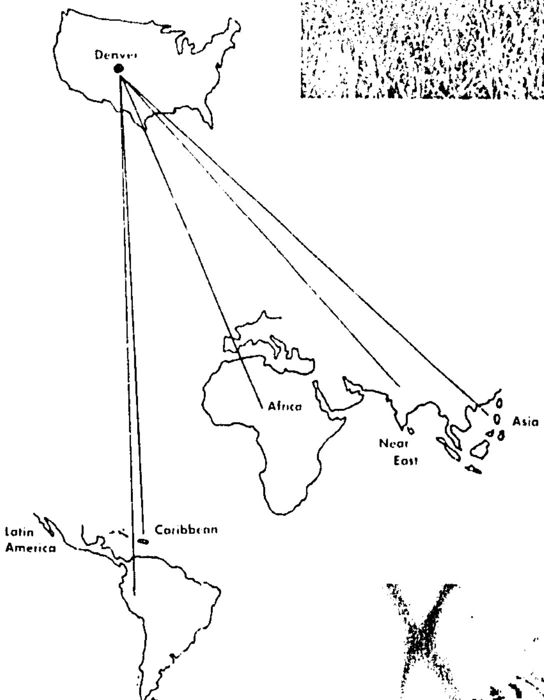
PN-AAU-437

VERTEBRATE DAMAGE CONTROL RESEARCH IN AGRICULTURE

ANNUAL REPORT 1984



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

U.S. Agency for International Development

PN-AAU-437

1984 ANNUAL PROGRESS REPORT*

SECTION OF INTERNATIONAL PROGRAMS
DENVER WILDLIFE RESEARCH CENTER

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Agricultural Agencies in Asia, Latin America, and Africa

International Agricultural Agencies

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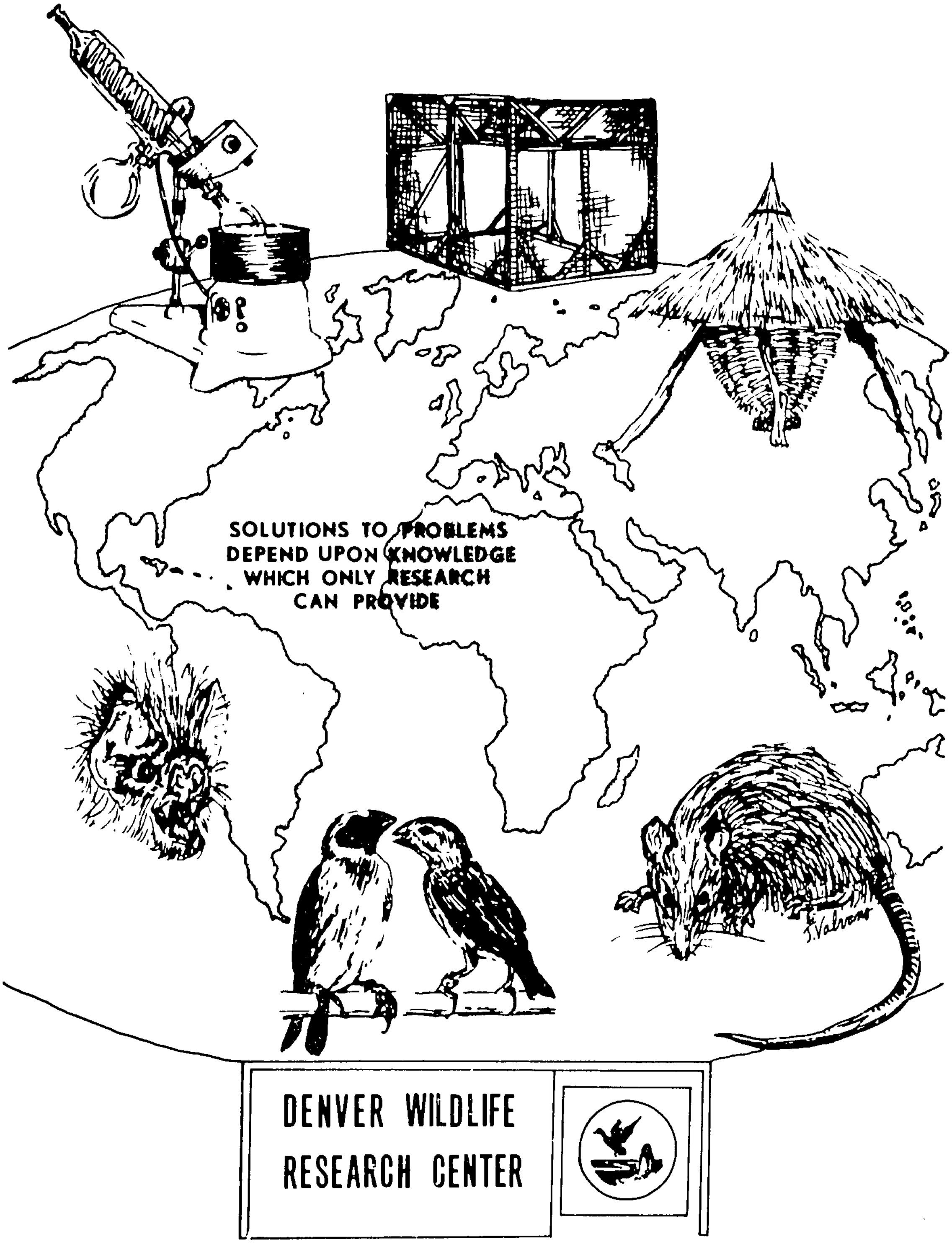
The cover illustrates the broad international scope of the USAID-sponsored International Programs of the Denver Wildlife Research Center (DWRC) and two of the most severe animal damage problems under investigation. Research at DWRC and in the field involves evaluating different control methods including chemical, physical, cultural, or other techniques that have potential for providing positive benefits by reducing vertebrate damage in agriculture. The pest species, crop, farming and storage methods, environmental factors, and a host of other considerations may influence the manner in which a particular problem is approached.

Vertebrate damage in agriculture involves a variety of crops and species of animals, primarily birds and rodents. Direct losses occur typically at planting and sprouting, during the milk or dough stages (for grains), just before harvest, or under posthavest storage conditions. Field programs are involved in trying to reduce or alleviate this damage in several countries of South and Central America, Africa, and Asia.

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

Losses to birds are less well documented than those to rodents. Various species of parrots, parakeets, blackbirds, weavers, doves, seedeaters, pheasants, and waterfowl are among the types of birds known to cause damage in agriculture around the world. Actual losses are difficult to assess because damage is usually concentrated in limited areas and, due to the mobility of birds, is often seasonal, sporadic, and hard to predict. The red-billed quelea in Africa is perhaps the most important vertebrate pest species in the world.


SOLUTIONS TO PROBLEMS
DEPEND UPON KNOWLEDGE
WHICH ONLY RESEARCH
CAN PROVIDE
DENVER WILDLIFE
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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 the Denver Wildlife Research Center of the U.S. Fish and Wildlife Service (USFWS) since 1967 under a Participating Agency Service Agreement (PASA) as provided for in Section 632B of the Foreign Assistance Act of 1961. The program goal is to evaluate these situations and, when circumstances warrant, develop methods to reduce or eliminate the damage. For many years, DWRC has been recognized as a leading organization in researching vertebrate pest damage problems and developing useful tools for vertebrate pest management. Its problem-solving team approach has led to developing and using new methods, materials, and techniques for vertebrate pest control, resulting in monetary savings in several developing countries.

The overall objective of this project is to increase the available human food supply in developing countries by reducing losses to vertebrate pests in both preharvest and postharvest situations. The ultimate aim of the pest management research program is to develop safe, effective, and economical control methods which are suitable and practical for traditional farmers and acceptable in the broader context of agricultural development. Self-sustaining, in-country programs are the expected end result of this project. Program goals are accomplished by (1) in-country programs, (2) outreach activities from the DWRC as requested by USAID/Washington, USAID Missions, or host countries, (3) supervisory and administrative functions from DWRC and USAID/Washington, and (4) problem-oriented research activities at DWRC through the Sections of Supporting Sciences, Bird Damage Control, Mammal Damage Control, and other components of the Center. Vertebrate damage problems in Africa, Asia, and Latin

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

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

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

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

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. Honacki, J. H.; Kinman, K. E.; Koeppl, J. W. eds. Allen Press, Inc. and The Association of Systematics Collections, Lawrence, KS. 694 Pp.

During 1984, 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 is in Port-au-Prince, Haiti, to serve the specific needs of Haiti and other regional countries.

During 1984, considerable effort was made by the DWRC Project Leader and Vertebrate Pest Laboratory staff to more completely document the vertebrate pest problem in Haiti. Crop production statistics were gathered and losses to vertebrate pests were described from questionnaire surveys or quantified from actual field assessments. Field studies evaluating flagging material as repellent for woodpeckers that damage maturing corn and a rodent problem survey on small farms were initiated. A study using bird-scaring reflection tape to protect grain sorghum from birds was conducted, and the breeding biology of village weavers was studied.

In September, the project leader returned to the DWRC ending 5 years of direct involvement in establishing an effective Vertebrate Pest Laboratory. DWRC will continue to provide short-term assistance as requested by USAID/Haiti and the Ministry of Agriculture.

Bangladesh

The Vertebrate Pest Control Laboratory (VPCL) continues to be a highly successful research program, and staff have been begun training extension personnel throughout the country. Because of the excellent participation in the National Rat Control Campaign in Wheat-1982/1983, a similar campaign was conducted in 1983/1984 in cooperation with the Bangladesh-German (GTZ) Plant Protection Programme. Studies were conducted to determine toxicity of rodenticides to common rodent pests; jackal and rat damage in sugarcane; the agricultural and economic importance of the jackal; the sensitivity of several bird species to copper oxychloride; simulated bird damage to sprouting wheat; myna damage to wheat seedlings in the aviary; and the repellent effects of bird-scaring reflection tape in maturing oilseed and grain crops.

Δ Damien - Site of Field Station

HAITI

Two field stations, located in Haiti and Bangladesh and involving resident U.S. biologists were continued during 1984 under the USAID/DWRC program. The broad goals of these programs were to increase food production and to reduce the risk of severe agricultural losses caused by vertebrate pests in developing countries. Specific objectives were as follows:

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

2. Develop new and adapt existing practical low-cost methods and technology to evaluate and reduce preharvest and postharvest crop losses to vertebrate pests of significant regional importance under local conditions.

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

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

HAITI

Breeding Biology of Village Weavers (*Ploceus cucullatus*)

Bird populations usually are lowest just before the reproductive season. The annual production of young replenishes the number of village weavers (*Ploceus cucullatus*) in Haiti, and because young usually outnumber adults after the breeding season, the young cause the greatest losses to grain crops in late summer and fall. In years of poor reproduction, crop damage should be less; this seemed to be the case in 1984.

Of ten colonies closely monitored in 1983, only five were occupied in 1984 (Table 1). The number of active males in the colonies was down about 70% in 1984, and nests were about 80% fewer than in 1983. Thus, with fewer males, fewer nests, and fewer nests/male (4.2 vs. 5.5) in 1984, undoubtedly, fewer young were produced.

Five of the colonies were located in acacia woodlands and five were in inhabited areas on the outskirts of Port-au-Prince. In 1983, the largest colonies were in acacia woodlands and accounted for 73% of the nests. Only one woodland colony was active in 1984; it contained only 7% of total nests and was deserted in mid-June. Numbers of breeding village weavers were down in 1984 near Port-au-Prince, and acacia woodland habitat did not support colonies. These changes probably reflected a decrease in the availability of food insects needed to sustain reproduction and illustrated the potential for reducing both the population of village weavers and the intensity of crop losses by limiting the insect biomass available to sustain successful reproduction.

Table 1. Numbers of breeding males and nests in village weaver (*Ploceus cucullatus*) colonies in Haiti.

Colonies	Maximum no. males 1983	Maximum no. males 1984	Maximum no. nests 1983	Maximum no. nests 1984
Acacia woodlands				
15 km	35	-	145	-
Gate	40	-	160	-
Shada N	60	-	300	-
Shada SW	35	-	350	-
Shada SE	68	7	468	24
Suburban locations				
Airport	20	-	80	-
Airport Pine	15	15	37	55
Flag	29	50	240	183
Radio Station	28	9	90	32
Gas Station	18	15	81	113
Total	348	96	1,951	407

In 1983, seven of the ten colonies formed early with nests being built primarily in June. In the remaining three colonies, nests were constructed in August and September. Adults had fledged their young and departed by mid-August in early colonies and by mid-October in late colonies. Old nests persisted for sometime in trees; the rate of their disappearance was unknown. The disappearance of 1983 nests in colonies was determined by periodically counting remaining nests until May 1984 (Table 2). This disappearance of nests varied considerably among colonies. A somewhat steady disappearance of nests was seen at Airport, Shada N, Shada SW, and Airport Pine, but the rate of loss was different. At most other colonies, the rate of loss varied over time, while at Gas Station no nests disappeared during the first 6 months. Rate of

Table 2. Disappearance rates for village weaver (*Ploceus cucullatus*) nests observed in colonies in the vicinity of Port-au-Prince, Haiti; 1983/1984.

Colonies	No. nests by dates					
	Maximum	21 Oct 83	2 Dec 83	2 Mar 84	19 Apr 84[a]	21 May 84[a]
Early nesting	Jun 83					
Airport	80	55	30	14	10/0	0/0
Flag	240	150	150	150	100/9	0/84
Radio Station	90	39	39	40	14/8	0/8
15 km	145	40	40	7	1/0	0/0
Gate	160	56	52	10	1/0	0/0
Shada N	300	163	138	22	0/0	0/0
Shada SW	350	300	80	30	11/0	1/0
Age of nests (months)	-	4	6	9	10	11
Late nesting	Aug/Sep 83					
Airport Pine	37	32	30	21	10/5	0/12
Gas Station	81	81	80	82	60/22	0/50
Shada SE	468	427	422	354	169/3	92/4
Age of nests (months)	-	1	3	6	7	8

[a] No. old nests (1983)/no. new nests (1984).

loss was related neither to the kinds of trees in which colonies were located nor to the nest construction material. Results showed that in some cases old nests can persist for almost 1 year. This was not expected, but does clarify why many colonies with fresh green nests often contained nests that looked much older.

Protecting Grain Sorghum From Birds

Bird damage to grain sorghum is serious and widespread in Haiti and is the principal deterrent to the production of this crop. In the past, sorghum fields matured at different times and were usually destroyed by village weavers, locally known as Madame Sarah, and yellow-faced grassquits (*Tiarus olivacea*). Farmers have reduced the problem by coordinating planting time and growing tall, photo-sensitive varieties that are not very productive but mature at about the same time.

Bird-scaring reflection tape that had been used to prevent damage in field trials in the United States, the Philippines, Bangladesh, and Nepal, was twisted and stretched over the sorghum fields to determine the effect on this situation. The method provided some protection from birds for about 7-10 days, but birds gradually became conditioned to the tape, and 25% sorghum was lost before harvest.

In another attempt to repel birds, netting was suspended over sorghum fields. This technique provided the most complete protection, but it is too expensive for use by Haitian farmers. However, in crop research schemes, where losses to birds often interfere with the collection of data and the interpretation of results, the approach may be practical.

Protecting Corn From Woodpecker Damage

Developing corn ears on experimental plots at the Damien Experimental Station have consistently suffered serious damage by Hispaniolan woodpeckers (*Melanerpes striatus*) that puncture ears and feed on the juices of the younger, growing ears. Between February and December 1983, woodpecker damage was measured in five experimental fields at Damien. Damage (expressed as the percentage of ears damaged) ranged from 32.8% to 56.7%. Several wrapping materials were identified in 1983 that successfully protected ears and reduced woodpecker damage, but wrapping proved to be tedious and expensive.

In 1984, red plastic strips (Saflag^R), 5x20 cm, were split at one end and attached onto the tip of young corn ears when woodpeckers first began damaging fields. Strips were placed on only about 7% of corn ears, but woodpecker damage was effectively reduced

In Haiti, "flagging" placed on maturing ears of corn protects them from woodpecker damage.

throughout the fields. In January, for instance, woodpecker damage was only 4.7% and 3.8% in two protected experimental fields. Additional tests of this technique are needed. Red plastic strips may help reduce woodpecker damage in corn, cacao, and other crops.

Small-farm Survey to Determine Rodent Activity

A small-farm survey was initiated on nine typical Haitian farms with a mixed-cropping system in the Croix-des-Bouquets, Cul-de-Sac Plain area, located 16-19 km northeast of the Vertebrate Pest Laboratory at Damien, to evaluate vertebrate pest activity and losses to agriculture. Three treatments were randomly assigned to the farms and included rodenticide baiting, snap-trapping, and no rodent control. One snap trap/100 m^2 of cropland was set for a minimum of 2 nights/month. One bait holder/1,000 m^2 of cropland, baited with 0.025% warfarin in coarse cornmeal was used. Bait holders were checked weekly, and, if needed, additional bait was added and holders were replaced. Rat activity was assessed 2 nights/month on all farms by tracking tiles.

The survey will be continued by Haitian scientists for several months. After 1 year, the data will be analyzed to determine vertebrate pest problems on small farms and provide potential solutions.

Field Testing Bird-resistant Sorghum

A sorghum variety developed in Kenya, called Muvemba and thought to be resistant to bird damage because of its high tannin content, was no more resistant to bird damage than other varieties when grown at the Damien Experiment Station. The Muvemba variety was planted with three other varieties in small plots for seed multiplication. Each variety was planted in four 5-m rows, adjacent to each other, at the edge of a larger corn field. Village weavers fed in the corn field and caused some damage to 35% of the corn ears. They also fed in the small sorghum plantings and ate about 75% of the seeds produced by each variety. Under these field conditions, Muvemba sorghum was as susceptible to damage by village weavers as the other varieties.

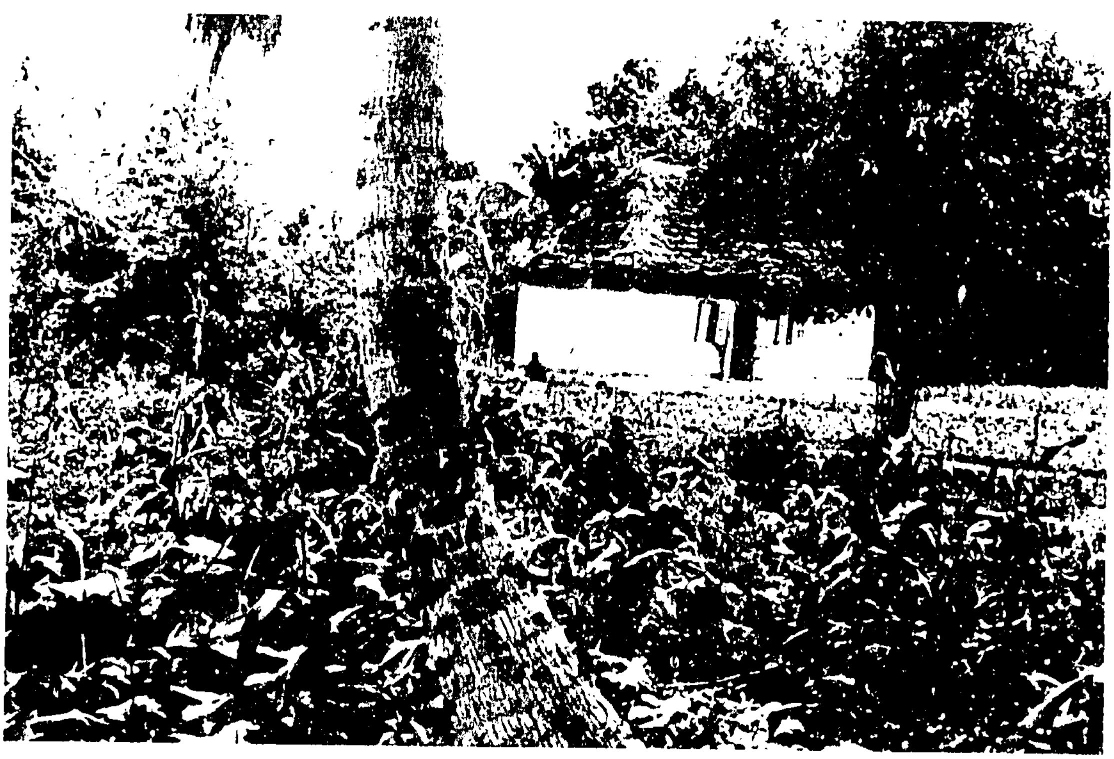
Cooperation With National and International Organizations

Communication and cooperation was maintained with district offices of the Ministry of Agriculture throughout Haiti. In this way, assistance and extension services were provided for the solution of some vertebrate pest problems. The Port-au-Prince district assisted in establishing our small-farm study in which crop losses and damage prevention techniques were assessed on several peasant farms in the Cul-de-Sac Plain.

Cooperation was continued with staff of Texas A&M University to evaluate vertebrate pest damage levels and the effectiveness of control techniques in experimental crops. At the Damien Experiment Station, Texas A&M agronomists grow small grains throughout the year. These crops suffer excessive damage during periods when few other foods are available for rats and birds. This schedule provides an excellent opportunity to evaluate crop protection systems, because vertebrate pest damage is concentrated on the small plots.

Personnel and Training

In late February, agronomists in Haiti participated in a Rice Seminar at the Mauge Experimental Station in the Artibonite Valley. In preparation for the seminar, numerous plantings of rice were begun 3 months earlier to illustrate the influence of different rice varieties, different planting dates, and different rates of fertilizers and trace elements on growth characteristics and yields. Jean-Paul Samedy used these rice plots to illustrate methods for protecting rice from rats and birds. He presented a paper describing the biology of these pests, the factors that increase the probability of damage to crops, and data needed to conduct effective vertebrate pest control.



On a typical multicrop small farm in Haiti the land is utilized to grow corn, melons, sweet potatoes, and bananas during spring.

GRAPHOSMAN

W.F.P., 1984

BANGLADESH

National Rat Control Campaign in Wheat[a]

Based on the success of the multimedia "National Rat Control Campaign in Wheat, 1982/83," a similar campaign was conducted during the 1983/84 crop season to retain the level of motivation for control activities by farmers. The preparation, organization, and evaluation of the 1983/84 campaign involved staff of the Department of Agricultural Extension (DAE) at the head office (mainly the Vertebrate Pest Control Section of the Plant Protection Programme) and in the field, Bangladesh-German Plant Protection Programme and the Vertebrate Pest Research Laboratory (VPRL) of the Bangladesh Agricultural Research Institute (BARI).

Total 1984 campaign costs were approximately US $36,000; $4,000 were contributed by the USAID-sponsored VPRL at BARI and the remainder by the Bangladesh-German Plant Protection Programme. The 1983/84 campaign was organized like the previous campaign, taking into account some of the recommendations that resulted from the evaluation of the 1982/83 campaign, during which wheat farmers were the major target group. In 1984, the campaign was expanded to include all farmers during the winter crop season.

The evaluation of the campaign was done as follows:

1. A management monitoring survey was conducted late January to monitor organization of campaign activities in the fields.

2. In March, just before wheat harvest, interview surveys and rat damage assessments in farmers' wheat fields in 10 districts were conducted by head office staff (Bangladesh-German Plant Protection Programme and VPRL of BARI).

3. The farmer's opinion was surveyed by a team of independent interviewers in nine districts. This survey was concluded in late April.

The campaign used all available mass media (radio, television, newspapers, posters, instructional leaflets, training brochures) and agricultural extension staff (Table 3). Posters, leaflets, and brochures were distributed to all district headquarters by head office staff from Dhaka. Agricultural extension staff then distributed the material to upazila and union levels.

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[a] Parts of this report have been extracted from a report by H. Posamentier and A. Van Elsen, Bangladesh-German Plant Protection Programme.

Table 3. Distribution of printed materials during the National Rat Control Campaign, Bangladesh, 1983/84.

Media materials	Districts	Upazilas (463)	Block supervisors (11,133)	Others[a]	Total
Posters	360	6,945	44,532	663	52,500
Instructional leaflets	12,000	46,300	1,001,970	10,393	1,070,663
Brochures	240	2,315	11,133	597	14,285

[a] Other organizations working with farmers and for use by head office staff.

Part of the campaign was a rat tail collection competition. Prizes were given to farmers, institutions such as schools, and staff for collecting the most rat tails. The competition was advertised via radio, newspapers, and instructional leaflets.

In 1983, approximately 80,000 ready-made bait packets were prepared and distributed by the Bangladesh-German Plant Protection Programme and the VPRL at BARI, while additional 140,000 packets were distributed by three private companies. In 1984, ready-made bait packets were prepared and distributed by five private formulators only. Bait packets (weighing 50 g) consisted of 2% zinc phosphide, crushed rice, wheat flour, and soybean oil, were cut into sun-dried, bisquit-size pieces and labeled with instructions for use and precautions; they were sold for about 12¢/packet. According to their reports, a total of 310,950 packets were distributed by mid-February to the districts, but the amount received in each district varied significantly from 35,000 packets received in Rajshahi to only 200 packets received in Bandarban.

Field surveys and farmer interviews were conducted by staff of the Bangladesh-German Plant Protection Programme and the VPRL at BARI. Wheat fields were assessed for rat damage by using 10 sample quadrats/field and counting all cut and uncut tillers in each quadrat. For all plots, average damage of 2.45% cut tillers was found (Table 4), and 68% of the plots showed evidence of rat infestation (cut tillers or rat burrows).

In 1984, of 805 farmers interviewd, 40% carried out some kind of control in the fields surveyed compared with 32% of 603 farmers interviewed in 1983. The percentage of farmers using control measures was higher in non-wheat-growing districts (45%) vs. wheat-growing areas (39%).

Table 4. Rat damage to wheat in campaign districts, Bangladesh, 1984.

District	No. fields surveyed	% cut tillers	No. infested fields
Comilla	90	0.74	51
Jamalpur	65	3.43	41
Tangail	95	2.83	54
Barisal	100	2.18	66
Faridpur	100	0.89	50
Noakhali	15	0.50	7
Dhaka	101	6.13	96
Dinajpur	100	2.13	77
Pabna	100	2.34	84
Rangpur	100	1.83	67
Total/Avg	866	2.45	594

In 1983, the ready-made bait was used far more widely than other rodenticides (Table 5), and its use in 1984 in non-wheat-growing districts increased sharply over that in 1983. The use of physical or mechanical methods (digging, flooding, smoking, or trapping) remained similar to those of the previous year and may, in fact, not seriously compete with use of rodenticides but rather be an additional activity. Ready-made bait was preferred over other rodenticides; wheat farmers are the major users during this time of the winter crop season.

Table 5. Control methods used in wheat fields during campaign, Bangladesh, 1984.

Districts	No. farmers using control	Farmers using: Ready-made bait No.	Ready-made bait (%)	Other poisons No.	Other poisons (%)	Other methods No.	Other methods (%)
Wheat-growing	249	113	(45)	104	(42)	80	(32)
Non-wheat-growing	71	38	(54)	30	(42)	16	(23)
Total districts/(Avg)	320	151	(47)	134	(42)	96	(30)

Of all wheat fields, 18.8% were treated with ready-made baits (151 of 805 respondents). Projecting to a total of 4,250,000 wheat fields in Bangladesh, approximately 797,000 were treated, indicating that about 300,000-400,000 bait packets (one packet for two to three fields) were sold to wheat farmers.

In 1984, damage reduction in fields treated with ready-made bait vs. fields without control was only 41% compared to 56% in 1983 (Table 6). This may be due to an earlier onset of heavy rat infestation and delays in the availability of the ready-made bait after opening of the campaign.

Table 6. Comparison of control methods and rat damage to wheat, Bangladesh, 1984.

Control methods	No. fields	% damage	% damage reduction relative to no control	Significance (t-test)
No control	165	4.90	-	-
Locally available poison	130	4.65	5	NS[a]
Mechanical/ physical	50	3.69	25	NS
Ready-made bait	150	2.88	41	0.001[b]

[a] Not significant.
[b] Difference between locally available poison and ready-made bait was significant at $P < 0.01$.

The approximate savings of wheat due to the use of ready-made baits by farmers are given in Table 7. While the absolute amount in monetary terms has risen from $480,000 to $720,000, the tonnage saved relative to the total production has risen only slightly (3.9% in 1983 to 4.1% in 1984). As in the previous campaign, savings in other crops, particularly savings of stored foods in villages and farmers' houses, must be added to the above figure.

A survey of farmers' opinions by interview was conducted. A total of 1,089 farmers in 18 different upazilas of 9 districts were interviewed, mostly while working in the field. Some of the data are summarized in Table 8.

Table 7. Savings through the use of ready-made bait in standing wheat in Bangladesh, 1983/84.

	Tons
Total wheat production, 1983/84	1,314,000
Wheat production in rat-infested plots (68%)	893,500
Production in plots treated with ready-made bait (30% of infested fields)	268,050
Loss at 4.90% (if no control)	13,134
Loss at 2.88% (if treated with ready-made bait)	7,720
Production saved through ready-made bait application	5,414
US $ saved through ready-made bait application (at $136/ton)	$736,304

During the 1983/84 national rat control campaign, a considerably larger farmer population was reached. The proportion of farmers who carried out rat control activities in their winter crops increased substantially from 49% of those interviewed in 1983 to 67% in 1984. Control methods in 1984 changed little from 1983, except for the use of rodenticides, which, in general, paralleled the increase in number of farmers doing control.

The use of ready-made baits increased fivefold, both in number of farmers who had seen the material in shops or the local market and those that had purchased and used it. The distribution of 310,000 bait packets by mid-February and the continued supply, plus the fact that the bait had been on the market for the past year, undoubtedly led to many farmers being familiar with the product. These results greatly exceeded expectations and more than met the quantitative indicators for a successful campaign. The amount of wheat saved, estimated from the reduction in rat damage in fields where the ready-made baits were used, gave an 18:1 benefit:cost ratio. This more than justified the efforts expended in this national campaign.

Table 8. Comparison of results of farmers' interview responses in 1982/83 campaign (N = 1,149) vs. 1983/84 campaign (N = 1,089) in Bangladesh.

	1982/83	1983/84
Percent of farmers knowing about the campaign	43	67
Most important source of information about the campaign (% of responses)		
Posters	22	53
Agricultural worker	11	42
Radio	36	39
Friend	31	24
Percent of all farmers doing rat control	49	67
Type of control used (% of responses)		
Rodenticides (locally available poison and ready-made bait)	46	67
Flooding	19	32
Trapping	18	20
Beating	26	16
Digging	6	8
Other	3	6
Use of ready-made bait (% of responses)		
Had seen ready-made bait	9	42
Had used ready-made bait	6	29
Rat tail collection scheme (% of responses)		
Farmers who knew about scheme	-	58
Farmers who collected tails	-	9

Laboratory Evaluation of Brodifacoum (Klerat) Wax Blocks

The relative palatability of a new Imperial Chemical Industries (ICI) brodifacoum wax block was compared with milled rice and wheat seed. The three test foods were offered separately in three food cups attached to the front of each cage. Six lesser bandicoot rats (*Bandicota bengalensis*) were given this choice for 3 nights. The position of the food cups was changed daily. One female rat ate 10.5 g of the 12.8 g of wax blocks consumed. None of the rats died. Results are summarized in Table 9.

Table 9. Daily consumption by *B. bengalensis* of three foods offered simultaneously in a laboratory experiment, Bangladesh.

Day	Food consumed (g)			Total
	Rice	Wheat	Wax block	(g)
1	28.7	27.3	3.4	59.4
2	12.0	21.9	6.5	40.4
3	17.5	12.8	2.9	33.2
Total consumption	58.2	62.0	12.8	133.0

Toxicology Evaluation of Bromethalin for *Bandicota bengalenis*

The acute oral LD50 of bromethalin for both sexes of *B. bengalensis* using the Litchfield and Wilcoxon method was found to be 2.62 mg/kg (95% CL 2.0-3.4 mg/kg). Results were similar to those for bromethalin for *Rattus norvegicus* (LD50 = 2.01 mg/kg for females and 2.46 mg/kg for males). In general, findings on the susceptibility of *B. bengalensis* to various toxicants have shown it to be about the same as for *R. norvegicus*. The low LD50 of bromethalin indicates it should perform well in the field.

Rat and Jackal Damage in Sugarcane

Three rat species, *Rattus rattus*, *B. bengalensis*, and *Nesokia indica*, and the golden jackal (*Canis aureus*) cause damage to sugarcane in Bangladesh. An intensive survey of vertebrate pest damage in five sugarcane fields in the Sripur area was conducted at the time of harvest in February. Three damage assessment methods were evaluated: (1) cutting and pulling all stalks from two randomly selected 5x5-m quadrats in each field. All stalks were examined for jackal and rat damage, the number of internodes per stalk were counted, and the number of jackal- and rat-damaged internodes was recorded; (2) the same procedure was carried out on two 2x2-m quadrats delimited by twine within each field, but without cutting and removing the stalks; and (3) the same procedure was used in an area delimited by attaching a 1.5-m long twine to a randomly selected stalk and noting damage and total number of stalks falling within the 1.5-m radius circle. No stalks were cut or removed using this method; approximately four samples were taken per field. The results of these assessment methods are summarized in Table 10.

The golden jackal (Canis aureus)

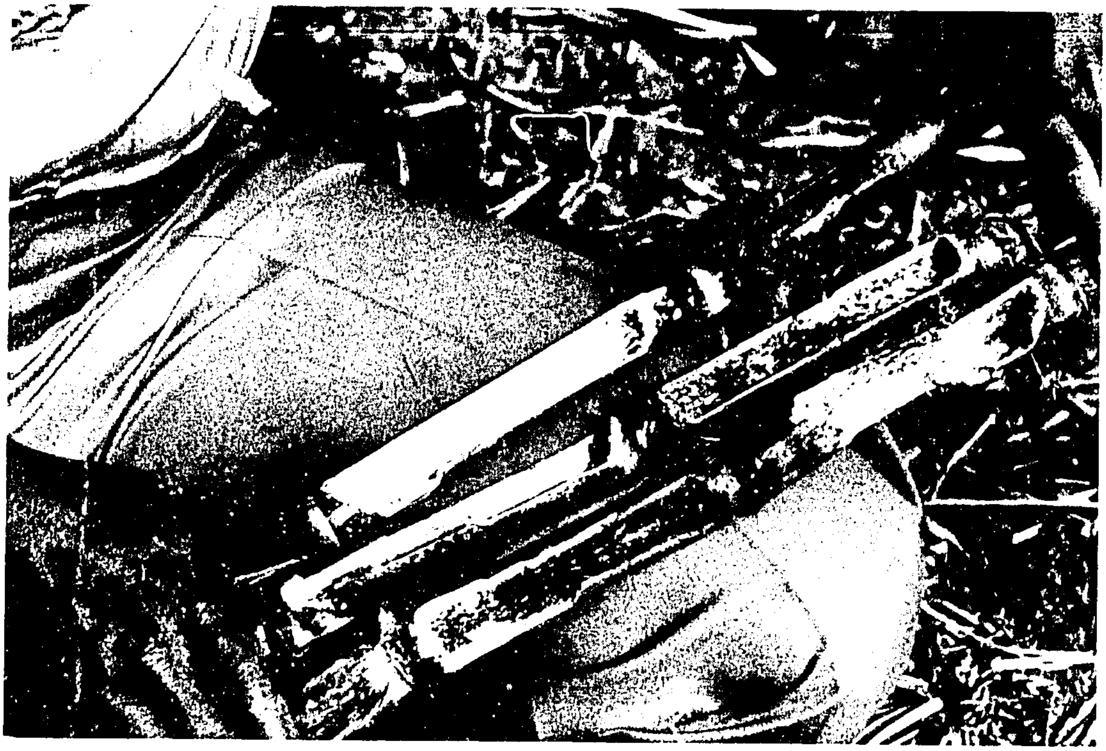
Table 10. Comparative assessment of jackal and rat damage in Sripur sugarcane fields, Bangladesh.

Observations	Quadrat size 5x5 m No.	%	2x2 m No.	%	1.5-m radius No.	%
No. samples	10		10		21	
Total cane stalks	2,095		463		1,189	
Canes damaged						
Jackals	521	24.9	105	22.7	291	24.5
Rats	262	12.5	27	5.8	30	2.5
Total internodes	35,623		8,071		20,953	
Internodes damaged						
Jackals	2,121	6.0	327	4.1	1,544	7.4
Rats	754	2.1	107	1.3	79	0.4

There was good agreement among methods when assessing jackal damage, but poor agreement when assessing rat damage. These results were probably due to jackal damage being fairly uniform throughout the fields, whereas rat damage was not uniform and damaged areas could easily have been missed in the smaller quadrats (2x2 m, 1.5-m radius).

The Agricultural and Economic Importance of the Golden Jackal in Bangladesh

Farmers' perceptions of the agricultural and economic importance of the golden jackal were determined by surveys of 11 representative districts in Bangladesh. Farmers were interviewed individually by staff of the VPRL at BARI, using a standard survey form. Information sought included crops damaged by jackals, total crop value, estimated value of crop losses, and the season when damage occurred. Numbers and value of domestic animals killed by jackals within the last year and the season when damage occurred were recorded. Interviewers inquired whether a farmer made any attempts at jackal control; what methods were used; when were jackals last seen or heard; and whether the jackal population was in-reasing, decreasing, or remaining about the same.



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

Of the 1,110 farmers interviewed, a total of 760 (68.5%) farmers reported problems with jackals, 286 (25.8%) reported damage to field crops, and 693 (62.4%) had lost domestic animals. The average farm income in Bangladesh is less than US $100. Total crop losses of those surveyed were estimated as US $10,145.60, or an average of $8.88/farmer for all farmers in the sample. The annual losses of domestic animals averaged $7.24/farmer. Aggregate losses for both field crops and domestic animals were $16.12/farmer. Extrapolating this to the 12 million farmers in Bangladesh would give an estimated $193 million lost annually due to jackal damage to crops and domestic animals. This ranks jackals second only to rats and mice as vertebrate pests of agriculture in Bangladesh.

Sugarcane was the field crop reported as most frequently damaged. Jackal damage to sugarcane stalks is more severe than rat damage; almost invariably the stalk is killed due to jackals crushing the intermodal areas between their jaws. Damage starts in July and continues until harvest in December/January. Watermelons and musk melons ranked next in frequency of reports. Farmers must guard their fields at night for 2 months while the melons ripen to minimize jackal damage. Jackals also attacked and damaged pineapple, jackfruit, maize, groundnuts, cucumbers, sweet potatoes, potatoes, gourds, and eggplant. Some crops, such as rice, jute, and wheat are accidentally damaged when jackals run, dig, or forage in these fields.

Concerning domestic animals, 589 farmers reported 4,223 chickens as killed by jackals, 231 farmers reported losses of 521 goats, and 162 farmers lost 632 ducks. A few reports were received of losses of pigs (9), cattle (5), pigeons (4), freshwater prawns (2), and sheep (1). Predation on chickens and goats was most intense in the months of May, June, July, and August.

Very few farmers have the resources or knowledge to protect their fields from damage by jackals. Only 42 (3.8%) reported doing any jackal control; the method most often used was chasing the jackals and killing them with sticks. Another method reported was guarding the fields at night.

Farmers were asked when they had last seen or heard jackals around their houses or village. In 1,072 replies, 616 (57.5%) had seen or heard jackals the night before, and 204 (19.0%) replied "sometime within the past week." Only 158 (14.7%) had neither seen nor heard jackals in their area for 1 month or longer. Some of these replies were from areas where monsoon rains had apparently driven jackals out to the nearest large areas of higher ground, leaving the smaller island areas devoid of jackals for the flood period. Jackal presence was reported, however, by one or more farmers in every village (220 surveyed) in each of the 11 districts.

Bangladeshi farmer is being interviewed by M. D. Haque, Vertebrate Pest Research Laboratory, BARI, to determine the agricultural and economic importance of the golden jackal.

The jackal is an opportunistic omnivore, intelligent, wily, and resourceful, yet well conditioned to the presence of man. The jackal seems to have successfully adapted to the densely populated, intensively cultivated agro-ecosystems of Bangladesh. Jackal control to reduce crop damage would seem to be justified in field crops such as sugarcane, melons, pineapple, and maize.

Bait Development for Jackals

The Vertebrate Pest Research Laboratory tested several baits to determine which, if any, would be preferred by the golden jackal. Several foods were offered to three caged jackals. All test foods were mixed with boiled rice, except beef fat and tallow. Jackals preferred raw chopped chicken and selected it as their first food to be eaten in 22 (73%) of 30 offerings. Beef tallow was the second choice, followed by raw egg, chopped shrimp, and beef fat. A bait consisting of beef tallow and chopped, cooked chicken molded into 40-g bait cubes was readily accepted by caged jackals.

Evaluating Copper Oxychloride as a Bird Repellent to Increase Wheat Yield

Pest birds pull wheat sprouts shortly after emergence and can cause a loss of 40 to 50% of the sprouts in farmers' fields. This can result in a yield reduction of 17 to 18%. Damage is caused primarily by pied mynas (*Sturnus contra*), common mynas (*Acridotheres tristis*), pigeons (*Columba livia*) and jungle crows (*Corvus macrorhynchos*). Chemical repellents applied to the wheat seed just before sowing can be used to reduce sprout loss to pest birds.

A field trial using a common fungicide, copper oxychloride, as a bird repellent on sprouting wheat was conducted in Gazaria Upazila. Ten fields were sown with Sonalika variety wheat seed treated with 1.25% copper oxychloride, and 10 fields were sown with the same variety wheat seed treated with 1.25% chalk powder. Chalk powder and copper oxychloride showed no effect on germination rate, which was 98-99%. The chalk powder was used as a reference, since all farmers demanded some chemical treatment for bird control.

Just before harvest, panicles were clipped from 10, 50x100-cm quadrats in each field. Panicles were counted, mechanically threshed after sun-drying, and weighed to the nearest gram. Yield data and panicle counts are shown in Table 11. Six fields (two treated and four reference) had already been harvested by the farmers, therefore, were not available for sampling. A *t*-test comparison of the mean differences, either panicle counts or yield, showed no significant differences between the treatments. Results of this test showed that copper oxychloride did not repel birds from feeding on sprouting wheat.

Common mynas (Acridotheres tristis) are responsible for losses to drying grain in village situations throughout Bangladesh.

Table 11. Panicle counts (no./m^2) and yields (t/ha) of wheat treated with 1.25% copper oxychloride or chalk powder in Gazaria Upazila, Bangladesh, March 1984.

Field no.	Copper oxychloride		Chalk powder	
	No. panicles/ m^2	Yield (t/ha)	No. panicles/ m^2	Yield (t/ha)
1	248.8	2.67	181.4	1.95
2	219.4	2.10	156.8	1.58
3	237.6	2.71	276.4	2.76
4	298.2	2.88	186.6	1.87
5	267.8	3.01	289.8	2.90
6	264.0	2.91	169.2	1.69
7	175.2	1.88	-	-
8	154.0	1.88	-	-
Means	233.1	2.50	210.0	2.12

Simulated Bird Damage to Sprouting Wheat

A study to determine simulated bird damage to sprouting wheat (20 days after sowing) utilizing a randomized block design was conducted in Gazaria Upazila on a 13.5x21-m experimental area. The study plot was divided into four blocks; each block was divided into 7 plots for a total of 28 plots. Each plot measured 2x2 m and was separated by pathways 0.5 m wide. The plots were marked with bamboo sticks and numbered tags. The experiment consisted of four replications with seven damage intensities--0%, reference; 5, 10, 15, 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 Sonalika wheat variety was sown at the rate of 60 kg/ha on 19 December 1983; sprouts were removed on 12 January 1984 to meet the required counts. Plots were fertilized and weeded. Rodent control was done in adjacent fields to prevent rat damage. The entire field was covered with a bird net during the sprouting period to prevent bird damage. Individual plots were harvested on 25 March 1984, 98 days after sowing. Panicles were tied into bundles and marked. Bundles were spread individually to sun-dry and were then mechanically 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. Results are shown in Table 12.

Table 12. Mean number of wheat panicles and wheat yield at different levels of simulated bird damage, Gazaria Upazila, Bangladesh.

Treatment (% sprout removal)	No. sprouts remaining/plot	Mean panicle count/plot	Mean yield/plot (g)
0	800	1,093.8	1,106.8
5	760	1,109.8	1,261.0
10	720	1,050,0	1,075.5
15	680	1,014.3	1,116.5
20	640	989.3	964.0
30	560	968.0	1,000.5
40	480	943.5	1,068.0

The experiment showed a definite trend in decreasing panicle counts with increasing sprout removal ($\underline{r}$ = 0.42707). The yield weights of the same samples, however, showed no such correlation. Analysis of variance showed no significant differences between blocks or treatments. Because panicle counts vs. treatment showed a declining trend relationship, it was suspected that yield samples might have been intermixed or mislabeled either before or after mechanical threshing. The experiment will be repeated under similar conditions.

Myna Damage to Wheat Seedlings in the Aviary

Two aviary trials were conducted to determine the effectiveness of methiocarb and copper oxychloride treatments to wheat seed. Sprouts of chemically treated wheat seeds were exposed in pots to 10 mynas (6 *A. tristis* and 4 *A. fuscus*). Wheat seeds were treated with 0.25% methiocarb or 1.25% copper oxychloride and sown at a rate of 100 seeds/pot; untreated seeds served as reference. Pots were repositioned daily. Germinating seeds were counted during the first 4 days, and damage was assessed by counting the number of seedlings remaining 10 days after sowing. In the first trial, methiocarb gave better protection; in the second trial, copper oxychloride excelled. However, there was less damage overall in the second trial, probably due to the same birds being again exposed to the same repellents. Results are given in Table 13.

Table 13. Percent of wheat sprouts removed by mynas after seeds had been treated with chemical repellents, Bangladesh.

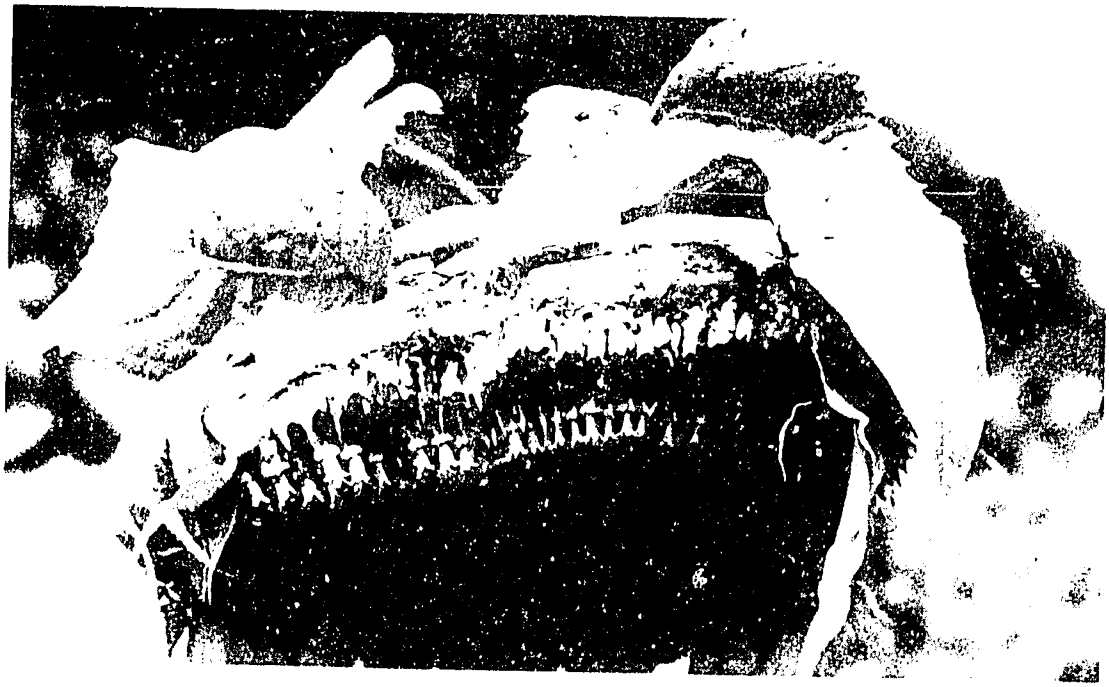
		% damage		
Trial	Replication	Reference	Copper oxychloride	Methiocarb
I	1	79	58	30
	2	60	20	25
	3	78	40	34
	4	66	54	23
Avg		70.8	43.0	28.0
II	1	51	16	24
	2	35	14	26
	3	48	13	28
	4	49	22	32
Avg		45.7	16.2	27.5
Avg both trials		58.2	29.6	27.7

Bird-scaring Reflection Tape as a Bird Repellent in Maturing Oilseed and Grain Crops

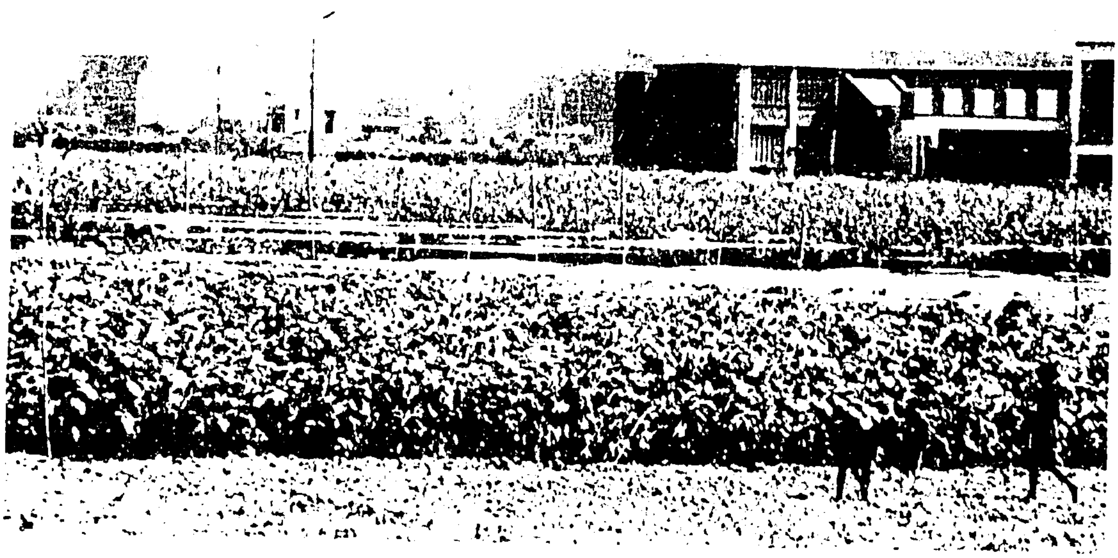
Several pest bird species severely damage maturing grain and oilseed crops in Bangladesh. Rose-ringed parakeets (*Psittacula krameri*) damage mature maize, sunflowers, wheat, and rice. Jungle crows (*Corvus macrorhynchos*) damage maize beginning at the milk and dough stages. Munias (*Lonchura* spp.) and house sparrows (*Passer domesticus*) damage foxtail millet, wheat, and rice.

The traditional method used in Bangladesh to minimize bird damage is to employ a bird scarer who patrols the field and frightens the birds by shouting and making loud noises. Another method is to use fluttering pieces of cloth or pieces of plastic sheet on bamboo sticks placed in the field.

Bird-scaring reflection tape was evaluated to determine its effectiveness in repelling birds from maturing crops. The tape was silver on one side and red on the other. It reflected sunlight to produce a flashing effect, and when stretched, it pulsated and produced a loud, humming, or sometimes thunder-like noise in the wind. Reflection tapes were installed over fields of sunflowers, maize, and millet. The tape was strung in parallel rows across the plots, just above the crop and slightly twisted.



Rose-ringed parakeets (*Psittacula krameri*) cause extensive damage in sunflower fields in Bangladesh.



Bird-scaring reflection tape, a red-and-silver nylon tape, protects sunflowers, millet, and maize from parakeets, munias, and crows in Bangladesh.

Field trials are conducted in Bangladesh to evaluate bird-scaring reflection tape.

Rose-ringed parakeets had eaten 23% of all sunflower seeds in the trial plot at Jessore when we installed reflection tape in late March. Before the tape was installed, an average of 12 parakeets and 6 sparrows fed per observation. Birds fed regularly throughout the day but numbers peaked during early morning and late afternoon. For 15 days after the tape was installed, virtually no parakeets entered the plot and damage ceased. Several sparrows occasionally reentered the plot, flying in beneath the ribbon to feed on seed on the ground. The flock of 18-25 parakeets remained in the area, loafing in palms surrounding the sunflowers. They often approached the sunflowers, but always returned to the trees, then fed in wheat stubble in an adjacent field. This effect was striking because parakeets generally are difficult to repel from sunflowers, especially after they establish feeding patterns.

In the trial to try to repel a resident population of 100-200 munias from plots of foxtail millet, the reflection tape caused birds to move between taped and untaped plots. This change occurred almost immediately each time the tape was moved. The morning the trial began (30 March), an average of 15 birds/count were feeding in Plot 1. For 4 days after the tape was installed, no birds fed in the plot, but 20-24 birds/count fed in Plot 2. At noon on 3 April, the tapes were switched to Plot 2, and birds immediately began feeding in Plot 1. However, on 8 April when both plots were covered with tapes, munias fed in both plots, reaching a peak of 60 birds/count in Plot 2 and 35 birds/count in Plot 1. These results suggested that reflection tape can repel munias from individual millet fields if an alternative food is available.

In the third trial at Jessore, parakeets avoided a maize plot with tape and fed elsewhere. A total of 8 parakeets and 70 other birds (mynas and sparrows) were counted during 150 observations over 15 days in the plot with tape; 111 parakeets and 507 other birds were counted in the untaped plot during the same time period.

Reflection tape also reduced damage to maize by jungle crows in a study at BARI, Joydebpur. An additional 5.3% damage occurred in one plot after tape was installed compared to a 9.9% increase in an unprotected plot. The number of birds counted feeding in the taped plot decreased 83% from preinstallation counts.

Cooperation With National and International Organizations

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

At the request of Mr. John Conway, Pest Infestation Control Specialist, Ministry of Food, laboratory evaluations of a paraffin-block anticoagulant bait were done at VPRL.

Technical advice, traps, and rodenticide baits were provided to the British Overseas Development Agency, Bangladesh Rice Research Institute (BRRI), to protect experimental deepwater rice plots and to the Diabetes Hospital, Dhaka, in an attempt to control rats that were damaging electrical cables on X-ray equipment.

Studies of rodent populations in farmers' houses continued as part of a cooperative effort with the Food and Agriculture Organization (FAO)/BRRI project on postharvest storage losses of paddy at the farm and village level.

During a visit at the Seventh Day Adventist Seminary School at Monosapara, Netrakona District, technical advice, traps, and rodenticides were provided. The school was experiencing severe problems with porcupine damage in their pineapple gardens. Baiting with coumatetralyl concentrate mixed with cubed, ripe pineapple stopped the damage within a few weeks.

Personnel and Training

Mrs. Parvin Sultana continued her postgraduate studies in International Vertebrate Pest Management at Colorado State University, Ft. Collins, Colorado. Mrs. Sultana will complete her studies in September 1985.

Mr. Shahabuddin Ahmad was chosen to work on an M.S. degree in Economic Ornithology. The university will be selected at a later date.

In September 1984, Mr. Rajat K. Pandit enrolled in an M.S. degree program in Agriculture (Entomology) with Bangladesh Agricultural University. He is taking classes at the Institute of Postgraduate Studies in Agriculture at Salna, Gazipur. Mr. Pandit's research topic is "The Biology and Ecology of *Rattus rattus* in the Gazipur District, Bangladesh."

In November 1984, Mr. Emdadul Haque enrolled in a Ph.D. program in Zoology at Dhaka University. His research topic is "The Biology and Ecology of the Short-tailed Mole Rat, *Nesokia indica*, in Bangladesh."

Radio Broadcasts: Five-minute radio talks on various pest management topics were broadcast in Bengali language on the Bangladesh Broadcasting System by all counterpart staff of the VPRL.

Mr. M. E. Haque	Insect problems and control in coconut. Insect problems and control in pomegranate. Rat problems and control in deepwater rice.

Dr. M. A. Karim	Rat problems and control in stored grains. General review of rat problems and their control in Bangladesh food crops.
Mr. Shahabuddin Ahmad	Pest bird problems and control in maize.
Mr. M. Y. Mian	Rat problems in stored foods and their control.
Mr. R. K. Pandit	Vertebrate pest problems in field crops and their control.

Vertebrate Pest Seminars: Half-day seminars on vertebrate pest problems and control, illustrated with color slides and narrative, were given at BARI regional (RARS) and subregional (SubRARS) Agricultural Research Stations, to personnel of the Thana Training and Development Center (TTDC), and to students and training staff at Agricultural Extension Training Institutes (AETI) from September through December (Table 14).

Table 14. Locations and numbers of participants at half-day training seminars on vertebrate pest control in Bangladesh.

Location	No. participants
Coconut Research Station, Rahmatpur, Barisal	30
SubRARS, Ramghar, Chittagong Hill Tracts	30
RARS, Hathazari	23
SubRARS, Raikhali, Chittagong Hill Tracts	28
SubRARS, Pahartali, Chittagong	20
BARI Farm, Jaintapur, Sylhet	30
TTDC, Monlovi Bazar, Sylhet	40
RARS, Dinajpur	225
AETI, Barisal	105
AETI, Hathazari	220
AETI, Sylhet	179
AETI, Dinajpur	112

During 1984, 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 411 man-days in the following countries:

Bangladesh	Costa Rica	Ethiopia	Italy
Nepal	Ecuador (Galapagos)	Kenya	
Pakistan	El Salvador	Niger	
Philippines	Haiti	Somalia	
Sri Lanka (Maldives)	Honduras	Sudan	
		Tanzania	
		Upper Volta	
		Zimbabwe	

Travel dates, persons involved, countries visited, and the purpose of each trip are outlined briefly in Table 15. Detailed information is contained in individual trip reports on file at the Section of International Programs, DWRC.

An important function of the Section of International Programs is to provide assistance to many countries and international organizations. During 1984, 184 requests from 63 countries were received and answered (Table 16).

Table 15. International travel for technical assistance projects by USAID/USFWS-DWRC personnel during 1984.

Date	Name	Location	Purpose of trip
8-31 Jan	R. L. Bruggers	Niger, Upper Volta, Kenya, Italy	Assist UNDP/FAO Regional Quelea Project personnel in eastern Africa to mark large numbers of quelea with fluorescent markers and plan future cooperative work. Discuss quelea book chapters with authors.
13 Mar-12 Apr	R. L. Bruggers	Bangladesh, Nepal, Philippines	Bangladesh: Assist project leader in study design and fieldwork. Nepal: Assess present status of vertebrate pest management. Philippines: Discuss present and organize future cooperative bird damage research studies with NCPC staff.
30 Mar-5 May	L. A. Fiedler	Philippines, Sri Lanka, Maldives, Italy	Philippines: Assist NCPC personnel in planning and implementing rodent control in coconut extension and evaluation program. Sri Lanka: Discuss vertebrate pest problems with FAO personnel. Maldives: Upon request by FAO, study rodent problem in coconuts and design control program. Italy: Briefing sessions with FAO personnel on vertebrate pest problems in the Maldives.
29 May-8 Jun	J. E. Brooks	Nepal	Survey vertebrate pest damage on small farms. Present seminars. Write project proposal.

Date	Name	Location	Purpose of trip
30 May-15 Jun	R. L. Bruggers	Nepal	Survey vertebrate pest damage on small farms. Present seminars. Write project proposals.
31 May-13 Jun	J. W. De Grazio	Pakistan, Bangladesh	Pakistan: Prepare draft scope of work and budget for possible assistance in vertebrate pest control. Bangladesh: Review project and plan future research and activities.
18 Jun-6 Jul	L. A. Fiedler	Haiti	Conduct small-farm surveys to assess damage by rodents and birds.
10-26 Jul	J. W. De Grazio	Ecuador, Galapagos Islands, Costa Rica	Ecuador, Galapagos Islands: Discuss ver-vertebrate pest problems on islands and mainland. Costa Rica: Discuss vertebrate pest damage to agricultural crops and livestock. Initiate test on tree-duck damage to emerging rice.
16 Jul-3 Aug	G. C. Mitchell	Zimbabwe	At the request of National Parks and Wildlife Management Department, assist in evaluating trimethacarb as a bird repellent to maturing wheat.
1-22 Aug	D. J. Hayes	Haiti	Set up laboratory and capture animals for training purposes.
27 Aug-20 Sep	L. A. Fiedler	Ecuador, Honduras	Discuss vertebrate pest damage problems in agricultural crops on the mainland of Equador and the Galapagos Islands with USAID/Quito personnel. Recommend methods for feral animal control. Honduras: Recommend bird and rodent control methods in rice and corn.

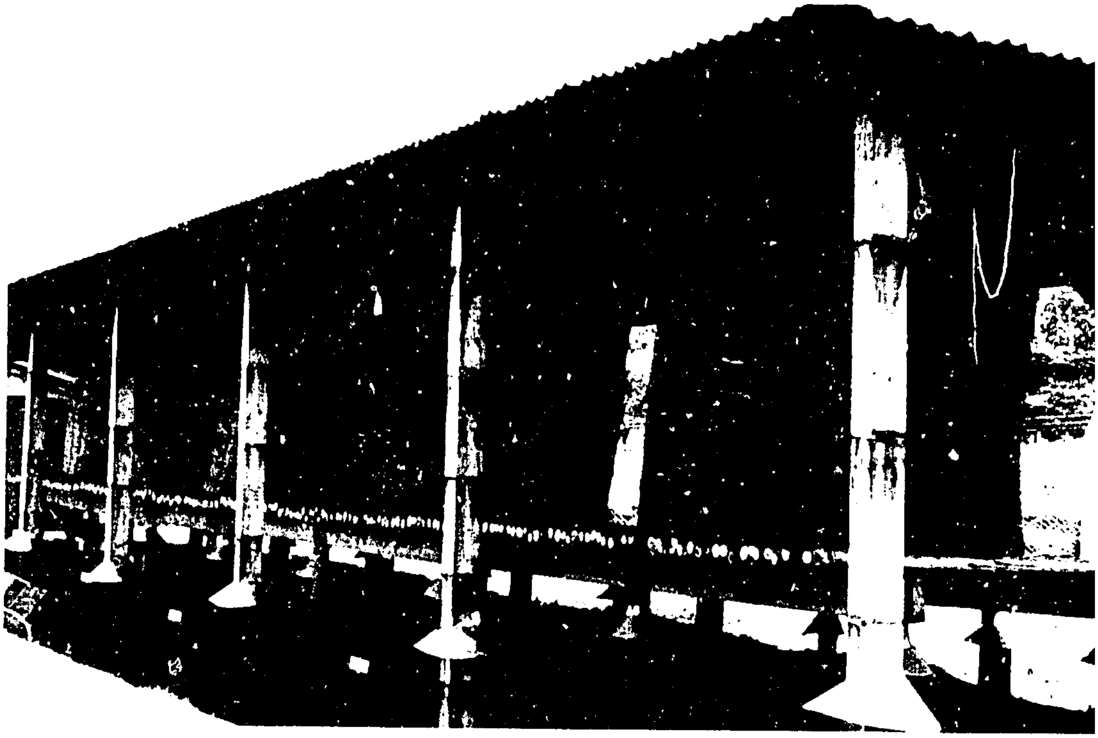
Date	Name	Location	Purpose of trip
10-28 Sep	J. O. Keith	Haiti	Prepare final report on the Vertebrate Pest Control project.
11-28 Sep	P. J. Savarie	Haiti	Provide technical assistance and instruct personnel in laboratory techniques.
1-16 Oct	R. W. Bullard	El Salvador	Evaluate vertebrate pest control and grain storage problems in El Salvador and make recommendations.
27 Oct-19 Nov	D. L. Otis	Kenya, Tanzania, Sudan	FAO consultancy with Project RAF/81/023 to determine techniques for aerially assessing areas of cultivated land and distribution of crops, and estimating bird damage.
29 Oct-12 Dec	L. A. Fiedler	Ethiopia, Somalia, Kenya, Tanzania, Zimbabwe, Italy	FAO consultancy to evaluate rodent problems in eastern Africa. Brief FAO personnel in Rome on findings.
5 Nov-2 Dec	R. L. Bruggers	Sudan, Kenya	Sudan: Discuss DWRC participation in bird damage control. Kenya: Participate in FAO-sponsored Technical Meeting on quelea research and management in eastern Africa. Organize cooperative field trials with FAO to evaluate the bird repellent trimethacarb and a bird-scaring reflection tape.
1-30 Dec	M. V. Garrison	Philippines	At request of Director, NCPC, assist NCPC personnel in study design and toxicity and repellency tests of avicides.

Table 10. Requests to DWRC for assistance during 1984. This table does not include requests to DWRC biologists stationed at field stations in Haiti and Bangladesh.

Type of request or activity	Months												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Information on International Programs	2	1	1	0	0	0	0	1	2	2	0	2	11
Literature or information on research and crop protection methods	12	9	8	5	4	4	4	8	3	10	5	5	77
Graduate school inquiries	2	0	0	0	0	0	0	1	0	0	0	0	3
Workshops/symposia/conferences	0	0	0	0	0	0	0	1	0	0	0	0	1
Materials/photographs	0	0	0	0	2	2	3	0	0	0	0	3	10
TDY's/visits/project requests	4	4	5	5	4	2	6	6	0	5	5	3	49
Hiring possibilities	0	1	2	0	1	0	0	2	1	0	0	0	7
International or visitors to DWRC	0	0	4	7	1	2	2	4	1	4	0	1	26
Funding	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	20	15	20	17	12	10	15	23	7	21	10	14	184

Originating countries:

- Jan Argentina, Australia, Brazil, Costa Rica, Egypt, El Salvador, India, Jamaica, Kenya, Mexico, Morocco, Niger, South Africa, Sudan, USA, Upper Volta.
- Feb Australia, Bolivia, Cameroon, Costa Rica, Guatemala, Honduras, India, Italy, Ivory Coast, Mali, Mexico, Peru, Tanzania, USA, Upper Volta.
- Mar Bangladesh, Brazil, Ecuador, France, Haiti, Honduras, India, Italy, Kenya, Mexico, Puerto Rico, Tanzania, USA, Vietnam, Virgin Islands, Zambia, Zimbabwe.
- Apr Grenada, Guatemala, India, Nepal, Philippines, Poland, Somalia, Sri Lanka (Maldives), USA, Zimbabwe.
- May Australia, Bangladesh, France, Ireland, Kenya, Nepal, Pakistan, Philippines, Switzerland, USA.
- Jun Bangladesh, Chile, Haiti, Kenya, Nepal, Pakistan, Philippines, United Kingdom, USA, Venezuela.
- Jul East Africa, West Africa, Australia, Bangladesh, Costa Rica, Ecuador (Galapagos), France, Honduras, Indonesia, Montserrat, Pakistan, Philippines, USA, Venezuela, Zimbabwe.
- Aug South Africa, Bangladesh, Canada, Costa Rica, Ecuador, Egypt, Germany, Haiti, Honduras, India, Israel, Japan, Kenya, Philippines, Sri Lanka (Maldives), USA, Venezuela.
- Sep Brazil, France, Philippines, Sri Lanka, Tanzania.
- Oct Argentina, Bangladesh, Colombia, Ecuador, Guatemala, Indonesia, Malaysia, Morocco, Nepal, Nicaragua, Pakistan, Philippines, Sri Lanka, Switzerland, USA, Venezuela, Zimbabwe.
- Nov Barbados, Ethiopia, Morocco, Kenya, Senegal, Somalia, Spain, Sudan, Tanzania.
- Dec Costa Rica, Ethiopia, Haiti, Iran, Kenya, Malawi, Nigeria, Sudan.



Improved maize drying cribs are being evaluated by USAID-sponsored storage project personnel in Kenya. These cribs are intended to permit early harvesting and reduce rodent infestation.

AFRICA

Cooperative Research

Since the closure of the USAID/DWRC Vertebrate Pest Project in Sudan in 1981, USAID/DWRC research activities on bird pest problems in Africa have been extremely curtailed. Our program consisted of laboratory work on evaluating less susceptible sorghum varieties, sensory cues to enhance methiocarb efficacy, trimethacarb field trials, and trace element analyses. A bird-scaring reflection tape study was conducted in Zimbabwe. DWRC's collaborative work with the Eastern Africa Quelea Project has been limited to supplying materials for aerial application of fluorescent particle markers, cooperating in repellent and tape studies, training, and planning a book and Experts' Consultation on quelea.

"Ecology and Management of the Red-billed Quelea"

This book will bring together much of the research, management, and training aspects of quelea work conducted during the past 20 years. Approximately 75% of the chapters are drafted and being reviewed. DWRC and FAO personnel are editing the book which will be published by Oxford University Press.

PROBLEM DEFINITION

Pakistan

During the last 2 years, DWRC biologists have assisted the Government of Pakistan in planning a vertebrate pest control project for possible implementation under the USAID/Pakistan-sponsored Agriculture Production, Distribution, and Storage (APDS) Project. In 1984, a DWRC biologist assisted in preparation of a scope of work document for these activities in the APDS Project.

Nepal

At the request of USAID/Nepal, DWRC helped the Government of Nepal survey rodent and bird damage in agriculture, assess alternative research and extension approaches to vertebrate pest control on small farms, and outline the requirements for implementing vertebrate pest management programs. Two seminars were presented to faculty and students at the Institute of Agricultural and Animal Sciences at Rampur.

Rodent Control in the Maldives, Indian Ocean

At the request of the Government of the Republic of the Maldives, FAO funded a DWRC consultant to evaluate rodent pest problems in coconut and recommend methods to reduce coconut losses to rodents. The Republic of the Maldives, with about 1,000 major islands, is a

During bait consumption comparison tests in the Maldives, baits were placed under a woven coconut frond roof to protect them from rain.

country dependent mostly on fish from the sea and coconuts from the land. Most coconut stands are not well maintained. Yields are low, with estimates ranging from 5 to 11 nuts/palm/year. Because nuts are small, seven nuts are needed to produce 1 kg of copra as compared to four nuts for 1 kg of copra in the Philippines.

Rattus rattus has been damaging coconuts in the Maldives since at least 1602. Damage estimates range from "severe" to more quantified estimates "as high as 40-50% of harvest." Only 50% of domestic coconut needs are met because of a decreasing number of coconut trees and an increasing human population. For this reason, FAO requested DWRC to evaluate the rodent problem, design a rat control program, and conduct preliminary training within the Ministry of Agriculture.

Rat activity and bait acceptance were determined (Tables 17 and 18) using tracking tiles and snap traps in coconut stands and village habitat. Low rat activity occurred in coconut stands compared with villages. However, during the day rats were readily observed in the coconut canopy; damaged, fallen nuts were seen, indicating an arboreal preference in coconut by rats.

Table 17. Rat activity determined from tracking tiles and snap traps on Kuramathi and Rasdoo Island, Alifu Atoll, Maldives, April 1984.

	Kuramathi Coconut stands		Rasdoo	
			Coconut stands	Village habitat
	21 Apr	22 Apr	23 Apr	24 Apr
Tracking tiles				
No. tiles	28	26	26	ND[a]
Marked tiles	1	2	0	ND
Activity (% marked)	3.6	7.7	0.0	ND
Trapping				
No. traps	28	26	24	25
No. rats	2	2	0	9
No. other animals	9	4	0	ND
No. traps sprung	5	8	1	ND
Bait used	Coconut cubes	Bread or fish	Coconut cubes	Bread or coconut cubes
Trap success (%, uncorrected)	7.1	7.7	0.0	36.0

[a] No data collected.

Table 18. Bait consumption comparison tests (paired choice), Kuramathi Island, Alifu Atoll, Maldives, April 1984. Between 1800 and 0600 on the day of the test, bait was placed in a plastic petri dish under a woven coconut frond roof.

	% bait consumption			
	Coconut stands		Village habitat	
Bait[a]	21 Apr	22 Apr	23 Apr	24 Apr
Klerat[R]	0	0	0	0
Talon[R]	5	11	50	ND[b]
Cornmeal	9	4	30	ND
Rozol[R]	ND	ND	ND	1
RMC[R] warfarin	ND	ND	ND	11

[a] Klerat - wax cube, grain base, red dye, 0.005% brodifacoum;
Talon - small pellet, grain base, green dye, 0.005% brodifacoum;
Cornmeal - from local market, no rodenticide;
Rozol - loose, mixed whole grain, 0.005% chlorophacinone;
RMC warfarin - loose, mixed, crushed, and whole grain, 0.025% warfarin.
[b] No data collected.

While snap-trapping in Male, the capital, a previously unreported commensal rodent, Rattus norvegicus, was caught. This species probably came to the island with imported goods regularly shipped from Colombo, Sri Lanka, or Singapore, or was introduced from a former Air Force base in a southern Atoll.

Status of Rodent Problems in East Africa

The FAO requested a DWRC consultant to evaluate rodent pest problems in Ethiopia, Somalia, Kenya, Tanzania, and Zimbabwe. Rodents cause significant crop damage throughout East Africa. The unstriped grass rat (Arvicanthis sp.) is common in East Africa from Tanzania north to the sub-Sahara region. It prefers savannah grassland and a herbivorous diet of grasses, inclucing wheat, barley, maize, sorghum, and teff. The multimammate rat (Praomys natalensis) is associated with human settlements throughout Africa. It is a true omnivore and consumes a variety of crops planted near villages as well as stored foods. This rat can transmit plague to humans via infected fleas. Under favorable conditions, the rat's mobility and high reproductive potential result in rapid population increases.

These two rats are responsible for the rodent "outbreaks" that periodically occur in East Africa. These outbreaks are usually associated with above-normal rainfall or rains that occur after a prolonged drought. Most countries have a rodent or vertebrate pest control unit within the Ministry of Agriculture, but the magnitude of these outbreaks usually overwhelms control efforts. A rodent monitoring and forecasting program, based on available and additional research results, would be extremely helpful to East African agriculture.

Several other rodent species can cause severe damage locally (Table 19). Grass mice such as *Rhabdomys pumilio* or *Lemniscomys striatus* and fossorial mole-rats (*Tachyroryctes splendens*) are frequently involved in field crop damage. The cane rat (*Thryonomys swinderianus*) damages crops cultivated near swampy or moist lowlands. Commensal rodents such as the brown rat (*R. norvegicus*), roof or ship rat (*R. rattus*), and house mouse (*Mus musculus*) are present. *R. norvegicus* is primarily restricted to the larger port cities; *R. rattus* is expanding its range in East Africa and is competing with *P. natalensis* as a common household pest. Gerbils (*Tatera* spp.) and some ground squirrels such as *Xerus rutilis* are present throughout East Africa and are particu- larly damaging to seeds at planting time. The crested porcupine (*Hystrix cristata*) damages any cultivated root crop and mature maize.

Control methods presently used include chemical baiting, a variety of physical methods including flooding or digging of burrows, and, to a much lesser extent, biological control such as weeding to reduce shelter for rats. Rodenticides being used include zinc phosphide mixed with cereal grain and, less frequently, anticoagulants. Laboratory and field efficacy trials are lacking for most chemicals and rodent species.

Ethiopia, Somalia, Kenya, and Tanzania have reported severe rodent pest damage. Ethiopia has been very active in conducting field surveys, experiments, remedial control projects, and training. Most other countries need to increase or strengthen support of their rodent control programs. With support from international organizations, rodent control programs can be strengthened in East Africa.

Table 19. Primary Rodent Pest Problems in East Africa.

Species	Distribution	Primary crops damaged
Arvicanthis sp.	Northern half of East Africa, grassland	Wheat, barley, maize, teff (small cereal grain)
Praomys natalensis	Ubiquitous	Wheat, barley, maize, stored foods, fruit
Rhabdomys pumilio	Grassy uplands	Wheat, barley, tree seedlings
Tachyoryctes splendens	Uplands, northeastern Africa	Pastural grasses, root crops, enset (false banana) and tree roots
Thryonomys swinderianus	Swampy areas from Sudan to Tanzania	Sugarcane, maize, rice, millet near marshes
Lemniscomys striatus	Ubiquitous	Seeds, most cultivated crops
Rattus rattus	Introduced commensal, extending its range in East Africa	Stored foods
Mus musculus	Introduced commensal, extending its range in East Africa	Stored foods
Rattus norvegicus	Port cities	Stored foods
Tatera spp.	Ubiquitous	Maize seeds, cassava, groundnut
Hystrix cristata	Ubiquitous	Potato, maize
Xerus rutilis	Northeastern Africa	Maize seeds

Introduced Rodent Problems in the Galapagos Islands, Ecuador

Feral animals introduced to the Galapagos Islands by pirates, explorers, and settlers have resulted in significant ecological damage to the unique, highly specialized biota (Table 20). Wild goats, cattle, and pigs destroy habitats by grazing. Pigs also prey on ground-nesting birds and turtle eggs. Wild dogs and cats threaten marine iguana populations and nesting birds. The roof or ship rat (R. rattus) readily adapted to most island environments and is seriously threatening nesting birds such as the dark-rumped petrel (Pterodroma phaeopygia), Galapagos tortoise (Geochelone elephantopus) hatchlings through predation, and native rodents through competitive exclusion.

Table 20. Feral animal control priorities in terms of ecological damage to the Galapagos Islands.

Species	Damage
Goats	Massive destruction of habitat through grazing
Pigs	Destruction of habitat; predation on nesting birds and turtle eggs
Cattle	Destruction of habitat through grazing
Rats	Predation on nesting birds and turtle hatchlings; competitive exclusion of native rodents
Dogs	Predation on marine iguana
Cats	Predation on nesting birds

At the request of USAID/Quito, a DWRC biologist evaluated vertebrate pest problems in Ecuador on the mainland and the Galapagos Islands. Rodents and birds damage several agricultural crops on the mainland (Table 21), however, little detailed information is available. Damage to agricultural crops also occurs in the Galapagos, but hectarage involved is small (<1% of the agricultural lands of Ecuador). On Isla Isabela, rat damage to pineapple, papaya, banana, sugarcane, and Citrus spp. was reported.

During the last 3 years, the dark-rumped petrel colony on Isla Floreana has made a remarkable comeback after a rat control project was initiated. Annual nesting success has increased from about 30% in 1982 to over 70% in 1984. A similar effort is being organized in a threatened petrel colony on Isla Santiago. DWRC will continue to provide guidance for this project which is conducted and supported by the Charles Darwin Research Station.

The iguana, one of many rare, endangered species on the Galapagos Islands, is preyed upon by feral dogs and cats.

Table 21. Agricultural crops damaged by vertebrate pests in Ecuador. (Identified by counterparts.)

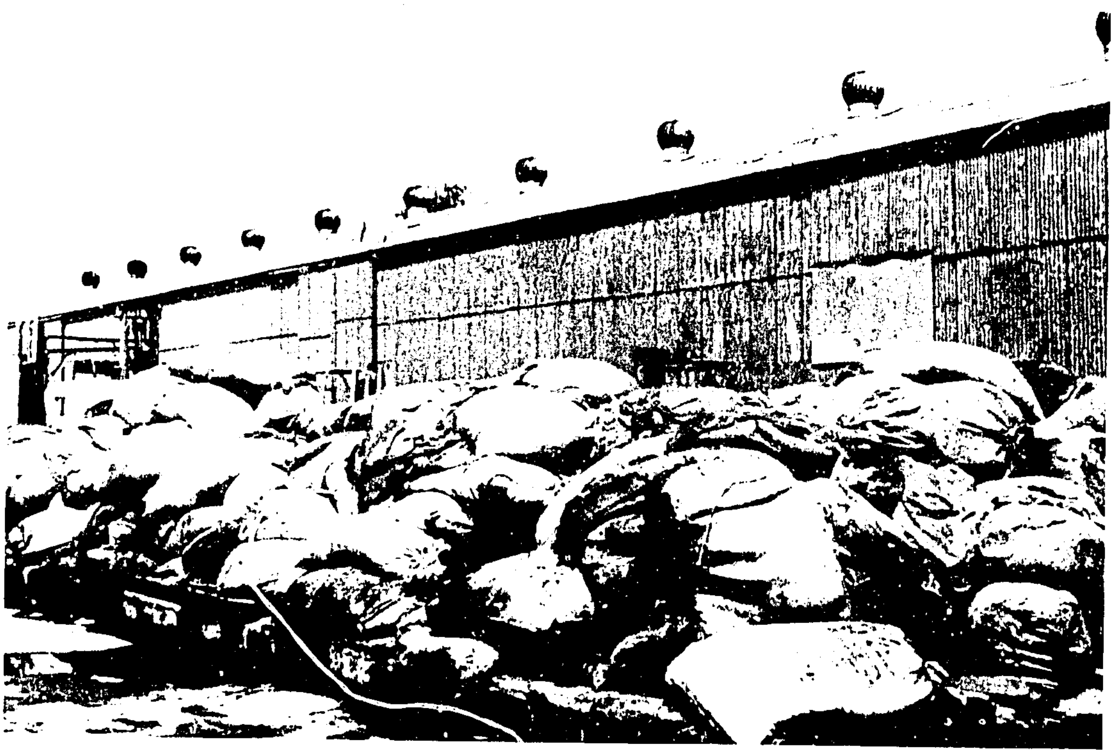
Pests	Crops
Rodents	Rice (mature) Corn (mature) Cacao Stored grain
Birds	Corn (mature) Barley (seeds) Wheat (seeds) Pine and lentil seed experiments
Woodpeckers	Cacao
Blue-winged teal (*Anas discors*)	Rice

While snap-trapping rodents in Puerto Ayora, Isla Santa Cruz, several Norway rats (*R. norvegicus*), previously unreported, were caught. This rat was probably introduced from the mainland by ships that anchor in Academy Bay and off-load goods to smaller boats that dock in Puerto Ayora and have no quarantine restrictions. Although presently restricted to urban areas, the Norway rat poses a potential threat to native species if it extends its range. Tourist and fishing boats that anchor near islands currently free of introduced commensal rats, threaten remnant native rodent populations such as *Oryzomys baurus*, which is only found on Isla Santa Fe. If *R. norvegicus* and *R. rattus* are introduced to Isla Santa Fe, *O. baurus* may become extinct.

Improved Grain Storage and Pest Control in El Salvador: Evaluation and Recommendations

The Food and Feed Grain Institute (FFGI), Kansas State University, and DWRC cooperated in an evaluation of grain storage and pest control problems in El Salvador. Engineering problems associated with transport and storage of cereal grains and vertebrate pest problems were evaluated.

Preharvest losses to vertebrate pests are at least as serious as losses in stored grain. Rodent infestations are periodically a serious problem in rice, sugarcane, and corn. The taltuza (*Pappogeomys* spp.), a large pocket gopher, burrows under growing crops and destroys the roots; granivorous birds cause serious



Grain sacks are often stored in the open which makes them more susceptible to rodent damage.

damage in sorghum, rice, and maize; and rats and mice infest government, milling, wholesale, and retail facilities.

Presently, the Centro Nacional de Tecnologia Agropecuaria (CENTA) is involved in vertebrate pest control in El Salvador. The DWRC specialist recommended several methods to control vertebrate pests in the field and in storage situations. However, preliminary research is necessary to determine major pest species, extent and nature of damage, and habitat conditions.

The solutions proposed for improving grain handling and storage techniques included: on-farm grain-drying procedures, dissemination of technical information to farmers through an extension program, price modification for grain purchased by the Institute Regulador de Abastecimientos (IRA), the reconstruction of IRA grain facilities, and the implementation of a solar drying program. In-country training by DWRC specialists was suggested for IRA and CENTA personnel as well as for private grain buyers and processors. University studies for CENTA specialists were also suggested.

Laboratory Trials With Trimethacarb and Methiocarb in the Philippines

Dr. Fernando F. Sanchez, Director, National Crop Protection Center, Philippines, requested assistance from DWRC to conduct laboratory toxicity and repellency tests of the avicides trimethacarb and methiocarb. The four species tested were *Lonchura malacca*, *L. punctulata*, *L. leucogaster*, and *Passer montanus*.

To obtain LD50 values, trimethacarb and methiocarb were either suspended or dissolved in propylene glycol and dosed by oral gavage. Values of *Lonchura* spp. were close when treated with methiocarb and showed approximately twice the toxicity of *P. montanus* (Table 22). Trials with trimethacarb showed that *L. punctulata* and *L. malacca* had similar LD50 values (4.16 and 3.13 mg/kg, respectively), while *L. leucogaster* and *P. montanus* showed much less toxicity (23.01 and 23.93 mg/kg, respectively).

During R50 trials, repellency values for trimethacarb were similar for the three *Lonchura* spp. The R50 values for both chemicals indicated a potential for protecting maturing crops from *Lonchura* spp. damage. Repellency values for *P. montanus* will be determined at a later date. Also, laboratory trials with copper oxychloride will be conducted as well as cage studies with all three avicides utilizing maturing potted rice and sorghum plants and individual or grouped species of birds.

Table 22. Toxicity and repellency values for methiocarb and trimethacarb tested on bird pest species in the Philippines.

Species	Methiocarb LD50 (mg/kg)	Methiocarb R50[a] (%)	Trimethacarb LD50 (mg/kg)	Trimethacarb R50[a] (%)
Lonchura punctulata	4.22	0.06	4.16	0.09
Lonchura malacca	2.37	0.04	3.13	0.05
Lonchura leucogaster	4.22	0.04	23.01	0.09
Passer montanus	8.66	ND[b]	23.93	ND

[a] R50 values for *Lonchura* spp. were obtained in previous trials.
[b] Not determined.

TRAINING

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

The academic program consists of courses such as

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

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

During the 4 years this program has existed, 37 students, including individuals from Bangladesh, Colombia, Ethiopia, Guatemala, Malawi, Nicaragua, Nigeria, Sudan, and Venezuela have enrolled. Several of these students have completed or are in the process of completing advanced degrees in a variety of topics relating to bird hazards to aircraft, bird pests in Bangladesh, vertebrate pests of Venezuela, and wildlife management in Sudan.

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

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

DWRC also continued to assist graduate student researchers in Vertebrate Pest Management at Bowling Green State University, at the University of California at Davis, at North Carolina State University, and at the University of the Philippines at Los Baños. The program at Bowling Green State University will place less emphasis on training of foreign students due to Dr. William B. Jackson's retirement in December 1984. Some candidates for advanced degrees visited DWRC during the year or conducted their research under the guidance of DWRC biologists.

Profiling, Mimicking, and Masking the Flavor of a Selected Rodenticide

Rodenticide baiting frequently becomes ineffective with certain relatively fast-acting toxicants such as strychnine. This problem occurs when rodents detect the flavor of strychnine in the bait after being adapted to the flavor of untreated food during a pre-baiting period. At this point, rodents ingest a very small amount of the adulterated food, receive sublethal toxic effects, and show extreme bait avoidance based on a conditioned flavor aversion. This essentially nullifies further control efforts. To reduce this impediment to rodenticide baiting, research was conducted to mimic or mask rodenticide flavors in order to counteract the flavor aversion effect.

Various methods have been used to gather information on the perceived taste qualities of materials to nonhuman species. One method is to teach an animal a specific response to one tastant and test for its generalization of that response to another. This procedure demonstrates that rats (Sprague Dawley-derived *Rattus norvegicus*) and hamsters (*Mesocricetus auratus*) tend to categorize tastants into four groups. By analogy to humans, these groups are called sweet, sour, salty, and bitter. In our experiments, a similar procedure was used, but for a different purpose. The aim was to determine whether generalization could be used to profile flavor components of strychnine, a rodenticide with known bait-aversion problems.

In Experiment 1, rats drank a small amount of strychnine solution and were then given an injection of lithium chloride (LiCl) to generate nonlethal toxicosis. Generalization of learned strychnine taste aversion to four nontoxic flavors was then assessed in the animals. Additional conditioning and generalization trials followed until 24 flavors had been presented. In Experiment 2, rats were conditioned to avoid individual flavors or strychnine flavor mimics blended according to the amount of generalized aversion observed in Experiment 1. Tests were then given for generalization of learned aversion from the simple flavors to the mixtures, from the mixtures to the simple flavors, and from either to strychnine. In Experiment 3, two concentrations of sodium chloride (NaCl) were mixed with strychnine or one of the flavors, sucrose octaacetate (SOA), used in previous experiments. These stimuli, as well as SOA alone, strychnine alone, and each of the NaCl concentrations, were presented to rats during conditioning. As in previous experiments, generalization followed. In Experiment 1, learned strychnine aversion generalized to the simple, bitter flavors ($P < 0.01$). In Experiment 2, aversion to flavor mixture mimics generalized more strongly to strychnine than learned aversion to simple flavors ($P < 0.01$). In Experiment 3, NaCl masked or otherwise suppressed the bitter flavor of strychnine or SOA, insofar as no groups conditioned with a bitter-salt mixture generalized aversion to the bitter flavor alone ($P < 0.01$).

Results showed that rats are capable of recognizing the flavor components of strychnine. Moreover, when these components are mixed in proportion to the degree of generalized aversion, a mimic of strychnine is obtained. Although these results are from laboratory tests, we believe that the methods can be effectively applied in the field to improve baiting efficacy.

Development of Radio Control Cannon Net Trigger

A digitally encoded radio control was developed to remotely trigger cannon nets for capturing birds. This prototype circuit can be programed with about 32,000 unique code combinations to prevent false triggering by extraneous signals. During a field demonstration, the remote control successfully triggered cannon net squibs at a distance of about 1.6 km. This distance exceeded the intended range for such a system and met the design criteria.

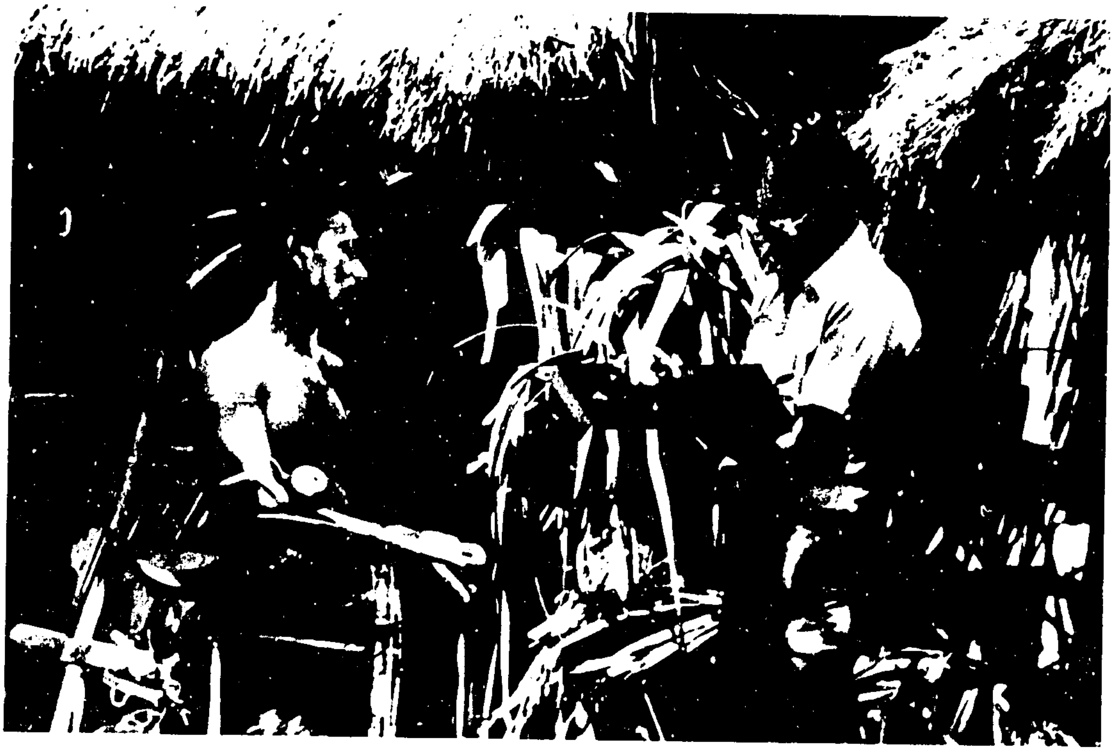
Postharvest Stored Food Losses: Estimation of Small-mammal Populations in Farmers' Houses in Bangladesh

In a previous study of small mammals in farm and village housing, we estimated an average of 3.0 rodents/structure and the annual losses of stored paddy (raw, unhusked rice) as 53 kg/household. This study underestimated both the rodent populations and the losses of stored foods because rat activity and trapping was only measured on the floor inside the houses. Tracking tiles, used to measure animals activity, and traps were given to the householder to place, and they invariably set them on the floor. Later observations made by placing tracking tiles on shelves, platforms, lofts (machas), and in paddy storage containers (doles) confirmed that about 70% of the small-mammal activity in farmers' houses takes place off the floor.

A redesigned study was initiated in June 1984 to more accurately assess small-mammal activity and population estimates from trapping data by placing tracking tiles and traps on the floor, on platforms, and in storage baskets. Village sites in a deepwater, rice-growing area in Mirzapur Upazila, Tangail District, were selected for study. Each month, tracking tiles were set one night, traps the next 3 nights, followed by another night of tracking tiles in 20 houses. The presence or absence of rat burrows in each house was recorded, also the farmer's estimate of the quantity of stored paddy in his house.

Results of tracking tile activity, animals captured, and estimated small-mammal populations are summarized in Table 23. The small-mammal populations were estimated by the change in proportion of tracking tile activity due to the removal of the small mammals during the 3 nights of trapping. Because toads were captured in rat traps, their captures were included in the overall population estimates, but their numbers were deducted to give the small-mammal estimates. The estimated small-mammal populations ranged from 72 to 552 per month during the 7-month period of this study.

Table 24 lists the animal species captured monthly. House mice remain by far the most prominent of the rodent species in farmers' houses. However, we now know that trapping results underestimate rat populations, particularly lesser bandicoot rat (*Bandicota bengalensis*) numbers. Since active rat burrows were recorded in an average of 79% of the houses, but bandicoot rats were captured in only 15 of 110 houses with bandicoot rat burrows (an average of 13.6%), it is obvious that rat traps are not taking this species in numbers commensurate with its presence.



During a survey to determine postharvest stored food losses, S. Ahmad, Vertebrate Pest Research Laboratory, BARI, talks to a Bangladeshi farmer in the Tangail District who assisted in measuring rat activity, trapping, and reporting amount of paddy lost.

Table 23. Tracking tile activity, number of animals captured, and estimated small-mammal populations, Mirzapur Upazila, Tangail District, Bangladesh, 1984.

Month	% positive tiles		No. animals captured	Estimated original population	No. toads	No. small mammals
	Pretrapping	Posttrapping				
Jun	20.8	16.5	29[a]	140	68	72
Jul	41.2	18.6	42[a]	77	5	72
Aug	46.7	30.0	46[a]	129	3	126
Sep	56.0	48.2	77	552	0	552
Oct	55.7	39.2	74[a]	250	7	243
Nov	36.9	26.7	62	224	0	224
Dec	34.3	27.0	80	376	0	376

[a] Includes toads: Jun--14; Jul--3; Aug--1; Oct--2.

Table 24. Animal species and numbers captured in farmers' houses, Mirzapur Upazila, Tangail District, Bangladesh, 1984.

Month	Species				Total
	M. musculus	*R. rattus*	*B. bengalensis*	*S. murinus*	
Jun	8	1	0	6	15
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
Total	279	19	36	56	390

Table 25 summarizes tracking tile data for the first 7 months of the study. About 65% of the positive tiles were on platforms or in baskets, both before and after trapping.

When we examined animal captures, there was a distinct stratification among different species. *M. musculus* was found at all levels, but predominated on platforms. *R. rattus* preferred platforms and baskets and was rarely taken on the floor. *B. bengalensis* preferred

Table 25. Tracking tile activity by location in houses, Mirzapur Upazila, Tangail District, Bangladesh, 1984.

Location	% positive tiles	
	Pretrapping	Posttrapping
Storage baskets	27.6	26.9
Elevated platforms	37.0	38.8
Floor	35.4	34.3

the floor and platforms, but can be found in baskets occasionally. *Suncus murinus* occurred mainly on the floor and was infrequently taken on platforms. These differences are summarized in Table 26. Sixty-six percent of the captures occurred off the floor. There was strong agreement between animal captures by location and tracking tile activity by location.

Table 26. Animal species by place of capture within farmers' houses, Mirzapur Upazila, Tangail District, Bangladesh, 1984.

Location	Species				Total
	M. musculus	*R. rattus*	*B. bengalensis*	*S. murinus*	
Baskets	72	5	5	0	82
Platforms	142	13	12	9	176
Floor	65	1	19	47	132

The combined estimates for rodent species gave a mean of 10.2 rodents/structure, which was more than a threefold increase over our previous estimates. These rats and mice can consume and hoard 70.7 kg of stored paddy/year/household.

Rice Husk Sweepings as a Measure of Rodent Consumption of Paddy in Bhogra Village, Bangladesh

A study was done to determine the feasibility of using rice husk sweepings, gathered daily from farmers' houses in Bhogra Village, as a means of estimating rodent consumption of stored paddy. Fifteen farmers agreed to save the daily rice husk sweepings from their houses, but only 12 farmers provided enough samples over a

6-week period to collect meaningful data (Table 27). Most samples were obtained from the floor, while much of the husks actually accumulated on elevated storage platforms and in woven bamboo storage baskets. Sweepings were placed in a plastic bag that was picked up weekly. The proportional weight of the husk to the rice grain was determined by examining 500 paddy grains; husks constituted 26.3% of the total weight. Samples contained rodent feces, thus, it could be determined which species--house mouse, roof rat, or lesser bandicoot rat--infested each household. Mean paddy storage per household at the start of the study on 24 September was 1,694 kg, which declined to 534 kg by 5 November, due to household use and sale of rice.

Table 27. Weekly paddy losses from farmers' houses in Bhogra Village, Bangladesh, and associated rodent infestation by species.

			Infestation		
House no.	No. samples	Mean weekly loss (g)	House mouse	Roof rat	Lesser bandicoot rat
1	5	494.3	+		+
2	2	250.8	+		+
3	6	535.1	+	+	
4	5	217.0	+	+	+
5	4	335.3	+	+	+
6	4	838.3	+		+
7	6	332.6	+	+	
8	6	173.7	+		
9	4	162.2	+		+
10	6	179.6	+	+	
11	5	234.3	+		
12	4	423.2[a]	+		
Totals/means	57	348.0	12	5	6

[a] Totals include rice husks winnowed from 255 kg of paddy stored for 11 months, which indicated a loss of 8.7 kg or 3.4%.

Mean weekly losses ranged from 162.2 g to 838.3 g. All houses were infested with house mice, five with roof rats, and six with lesser bandicoot rats. Examination of daily rice husk sweep samples is an easy way to determine rodent infestation and species composition in farm houses and more accurate than the use of tracking tiles or traps, which, in these same houses, showed that only 64% were rodent infested.

The mean loss of paddy/week/household was 348 g, which was minimal because many husks were still lying on platforms and in woven bamboo storage baskets that are cleaned infrequently, indicating a possible annual loss of 18 kg/family. This estimate does not include any paddy hoarded by lesser bandicoot rats in their burrows in the foundation floors of farm houses.

Estimating Rodent Populations and Damage to Stored Wheat

At DWRC, a study involving closed colonies of house mice was initiated to develop better methods for estimating rodent damage to stored wheat. An assessment of the effects of mouse population density on wheat consumption and contamination levels was needed to evaluate previously proposed damage estimation techniques and the utility of other measured variables (for example, water consumption or photocell breaks) as indices of rodent activity and damage.

Two population density levels were compared. Fifty wild house mice (25 male and 25 female adults) were released into a 34.2-m^2 room within a brick and concrete rodent-proofed building. At the same time, 100 wild mice (50 male and 50 female adults) were released into a second 34.2-m^2 room in the same building. Both mouse colonies were adapted to attached 1.7-m^2 harborage areas and to feeding on whole wheat in 1.2x1.5-m open wood storage bins. When water and food consumption levels stabilized after 2 weeks, 114 kg of winter wheat were placed in each open bin. During the next 30 days, mouse activity was measured twice weekly using water consumption and photocell break counts as indices. Also, during this period, two 8-day live trapping sequences were conducted to capture, mark, and recapture individual mice. A census was made after a 30-day test period by capturing all the mice in each colony. Pregnancy rates, body weights, and signs of fighting were assessed. The wheat was reweighed and ten 25-g samples were taken from each bin for evaluations of urine, droppings, and hair contamination). The test procedure was then replicated with new groups of mice.

Preliminary results of these tests are summarized and compared with estimated values in Table 28. Natural mortality from fighting and low natality-pregnancy rates resulted in reduced colony populations at the end of the 30-day period. The Lincoln-Peterson index was used to estimate mean colony sizes from the capture-mark-recapture data. Estimated values tended to be only about half of the actual mean colony sizes. The weight of consumed wheat was probably biased and distorted by urine and fecal contamination, but the results indicated a trend toward lower consumption/mouse/day in the denser (N = 100) colonies (3 and 4). Mean body weights of mice in the two lower density (N = 50) colonies (1 and 2) also tended to be greater, possibly because of less social stress. Based on the mean colony sizes and the assumption recommended by J. H. Greaves that mice consume approximately 15% of their body weights/day in grain, the calculated estimates were generally below the measured food consumption levels (12-47% lower). Overall, house mice in all colonies consumed approximately 19.7% of their body weights/day in grain under our test conditions.

Contamination data and population estimates based on water consumption and photocell break data are being analyzed. Mean daily values for these variables are shown in Table 28. The Lincoln-Peterson index tended to underestimate population sizes. Colony sizes of 25 vs. 12 will be examined in the next phase of the research. When completed, this experiment will provide an evaluation of the reliability and accuracy of stored grain damage estimation via population sampling, water consumption, and activity sensing methods.

Table 28. Actual and estimated colony sizes, wheat consumption, water intake, and photocell break counts in four *Mus musculus* colonies in 30-day tests.

	Closed colony number			
	1	2	3	4
Size at start of test	50	50	100	100
Size at end of test	36	42	72	80
Mean colony size	43	46	86	90
Lincoln-Peterson Index; estimated mean size	23.0	27.5	35.0	51.5
Total wheat eaten in 30 days (kg)	5.36	7.61	8.04	10.90
Mean ± SD body weights of mice (g)	22.19±2.90	20.54±2.59	19.48±2.82	19.35±3.24
Actual total consumption/day (g)	162.1	271.4	243.3	388.8
Estimated total consumption/day (g) (using J. P. Greaves method)	143.1	141.7	251.2	261.2
Mean ± SD water intake/day (mL)	136.0±21.4	137.4±12.9	191.3±51.7	198.2±16.8
Mean ± SD photocell breaks	2,402±850	2,534±819	4,141±1,742	2,066±419

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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 except as otherwise indicated.

[4] Individuals who cooperated with the project in research, extension, or project development activities.

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Date	Name	Representing
10-20 Jan	Ms. Maria Elena Leon	Venezuela (Student at CSU)
9 Mar	Mr. Ernest G. Mosha	Quelea Control Project, Arusha, Tanzania
9 Mar	Dr. G.G.K. Schulten	Food and Agriculture Organization, Rome, Italy
9-25 Mar	Mr. Yousuf Mian	Bangladesh Agricultural Research Institute, Joydebpur, Bangladash
12-13 Mar	Mr. and Mrs. Mike LaGrange	Problem Animal Research and Control Unit, National Parks, Zimbabwe
19 Apr	Dr. Dorsey Davy	International Agricultural Development Service, Bangladesh
8 Aug	Dr. Phil Alkon	Ben Gurion University, Institute for Desert Research in the Negev Desert, Israel
17 Sep	Mr. Dalgas Frisch	Dalgas-Ecoltec Company, World Wildlife Fund, Sao Paulo, Brazil
18 Oct	Graduate Students from Colorado State University, Fort Collins, Colorado:	
	Ms. Yusmary Espinoza	Venezuela
	Ms. Sylvia Estrada	Nicaragua
	Ms. Sonya Renee Ubico	Guatemala
	Mr. Danilo Valencia	Colombia
10 Dec	Mr. Jeff Marley	Margo Horticultural Supply, Ltd., Calgary, Canada
10-12 Dec	Mr. Amir Sh. Vaziri	Plant, Pest, and Disease Research Institute, Rodent Laboratory, Teheran, Iran

Brooks, J. E. "Vertebrate pest problems in Bangladesh." Presentation at the Institute of Agriculture and Animal Sciences, Rampur, Nepal; 7 June 1984.

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Karim, M. E. "Pest birds of Bangladesh and their control." Presentation at the Crop Production and Extension Resources Management Specialist Training Course, Central Extension Resources Development Institute, Joydebpur, Bangladesh; 19 April 1984.

Mian, M. Y. Attended 11th Vertebrate Pest Conference, Sacramento, California; 6-8 March 1984. Worked with scientists at DWRC, Denver, Colorado; 9-25 March 1985. Reviewed work on postharvest losses of stored foods and methods to prevent losses at Kansas State University, Manhattan, Kansas; 26-28 March 1984.

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NOTE: Further information on special reports can be obtained from DWRC.

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