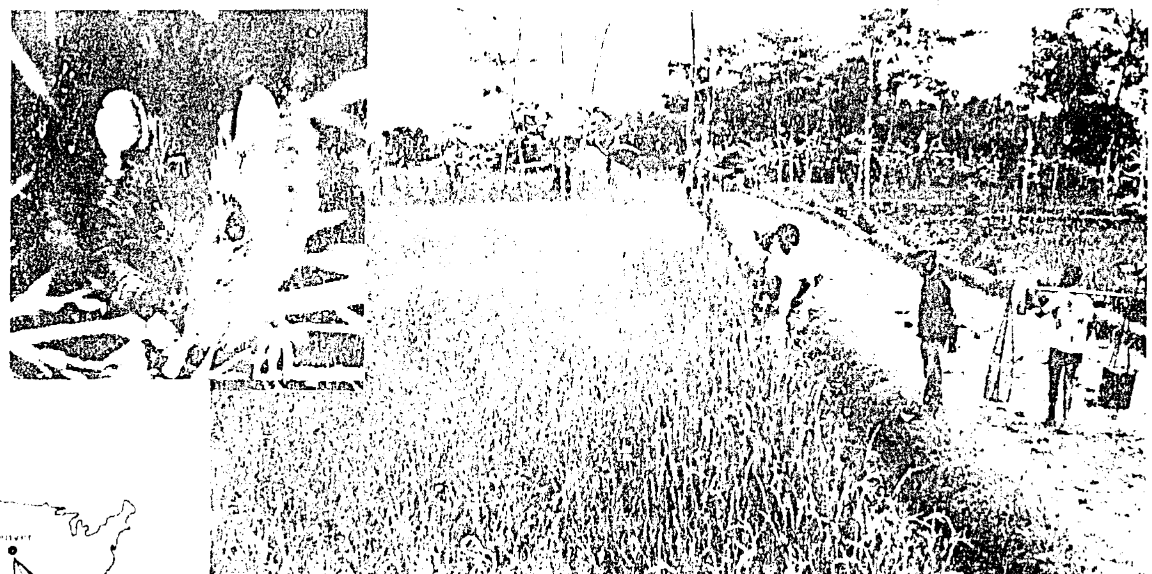
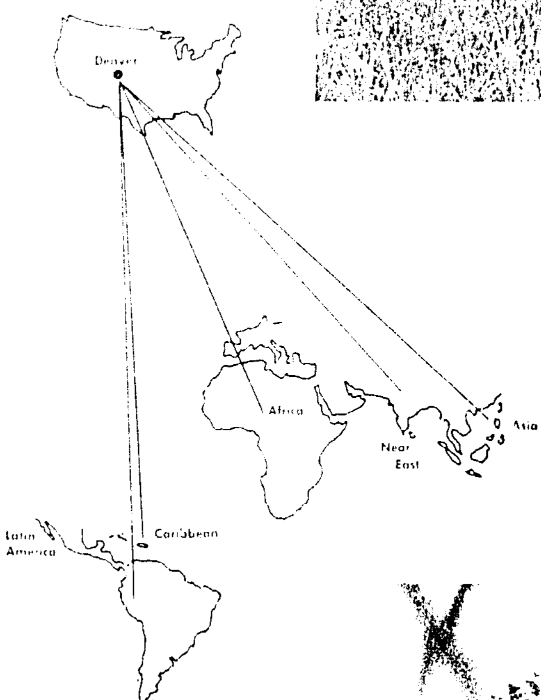
VERTEBRATE DAMAGE CONTROL RESEARCH IN AGRICULTURE

ANNUAL REPORT 1987





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

Agency for International Development

1987 ANNUAL PROGRESS REPORT

INTERNATIONAL PROGRAMS RESEARCH SECTION
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"Agricultural Research II Vertebrate Pest Management Component"	IBD-0051-P-IF-2252-05
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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: rodent and bird damage to agricultural crops both pre- and postharvest. Research at DWRC and in the field involves evaluating a variety of 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 during postharvest storage conditions. Field projects conduct studies 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; 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.

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

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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.

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

The overall objective of this project is to increase the available human food supply in developing countries by reducing losses to vertebrate pests in both preharvest and postharvest situations. The ultimate aim of the pest management research program is to develop safe, effective, and economical control methods which are suitable and practical for traditional farmers and acceptable in the broader context of agricultural development. Self-sustaining, in-country programs are the expected end result of this project. Program goals are accomplished by (1) in-country programs, (2) outreach activities from the DWRC as requested by USAID/Washington, USAID Missions, or host countries, (3) supervisory and administrative functions from DWRC and USAID/Washington, and (4) problem-oriented research activities at DWRC. Vertebrate damage problems in Africa, Asia, and Latin America are continuously reviewed with the aim of adapting current techniques or materials to specific problem situations in a crop protection-oriented management program which will provide an effective means of long-term crop protection.

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

The International Programs Research Section (IPRS) of the DWRC provides support and direction to field personnel, assists in establishing relevant research objectives for laboratory personnel, and coordinates the team efforts of DWRC and cooperating scientists. The experienced DWRC staff is composed of specialists in diverse fields such as pesticide contamination, 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.

References used for names of birds and mammals:

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

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

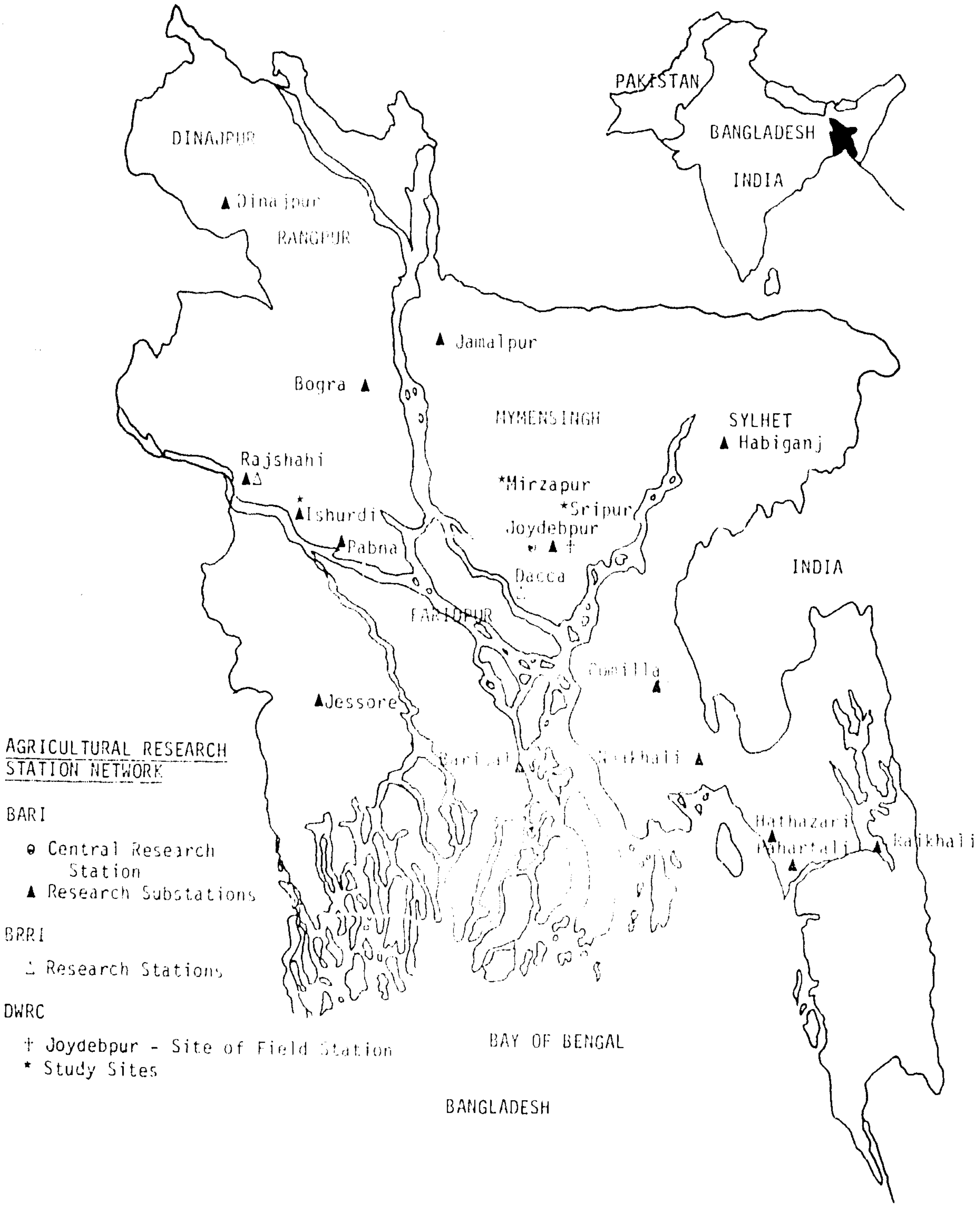
During 1987, the broad goals of field stations in Bangladesh and Pakistan continued to be increasing food production and reducing the risk of severe agricultural losses caused by vertebrate pests. Special objectives are:

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

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

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

Provide training at DWRC and appropriate universities to perfect capabilities of counterparts to conduct programs in vertebrate pest management.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RANGPUR
Jamalpur
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Mirzapur
Sripur
Ishurdi
Joydebpur
Pabna
Dacca
INDIA
FARIDPUR
Comilla
Jessore
Hathazari
Pahartali
Kaikhali
AGRICULTURAL RESEARCH STATION NETWORK
BARI
Central Research Station
Research Substations
BRRI
Research Stations
DWRC
Joydebpur - Site of Field Station
Study Sites
BAY OF BENGAL
BANGLADESH

BANGLADESH

The Vertebrate Pest Control Laboratory (VPCL) continues to maintain a highly successful research program, and staff are training extension personnel throughout the country. The VPCL will develop practical control techniques and strategies and will implement these strategies through an extension program.

Research Work Plan

During 1987, USAID extended support of the Vertebrate Pest Component of the Agricultural Research Project (ARP) until October 1990. The extension will allow for completion of ongoing research and implementation of results of the previously developed work plan. The principal objective of this research is to increase food production in Bangladesh through effective vertebrate pest control at the farm level.

During 1987, research emphasized fieldwork to develop control strategies to reduce:

1. preharvest rodent damage to rice and wheat;

2. postharvest mouse and rat damage to grain stored in farmers' houses; and

3. jackal damage to sugarcane, chickens, fruits, and vegetables.

Research was conducted at two study sites (Fig. 1) that represent the two principal agro-ecological zones where rice is grown: Ishurdi, wet plain (transplanted rice), and Mirzapur, floodplain (deepwater rice).

Preharvest Rodent Damage

The need to develop an annual strategy for rodent control rests on the following assumptions:

1. rodents are a chronic problem in Bangladesh;

2. long-term population reduction is not practical, and, therefore, annual control is necessary;

3. a regular seasonal cycle occurs in the fluctuations of rodent numbers caused by naturally occurring factors, such as cover and predation, which change the balance between natality and mortality; therefore,

4. there are predictable times of the year and places where control can be most effective for reducing damage.

Countrywide production estimates for each of the three rice crops and for wheat show that cereals are grown throughout the year. The major cereal crop is aman rice that is grown with the main rains (June to September) and harvested in November and December (Fig. 2).

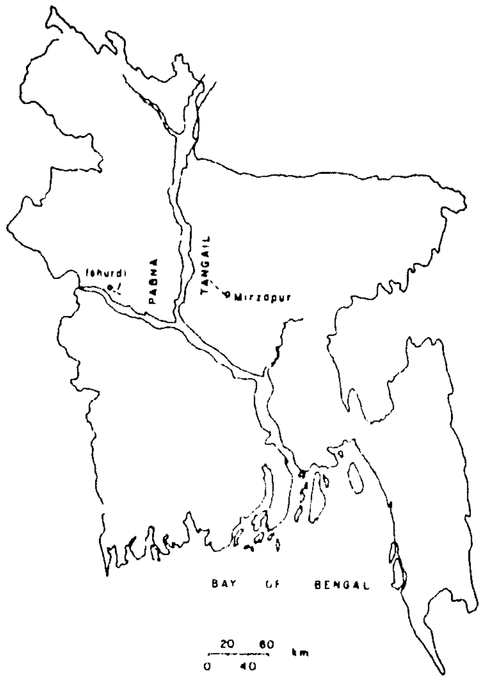


Fig. 1. Map of Bangladesh illustrating the location of study sites at Ishurdi and Mirzapur.

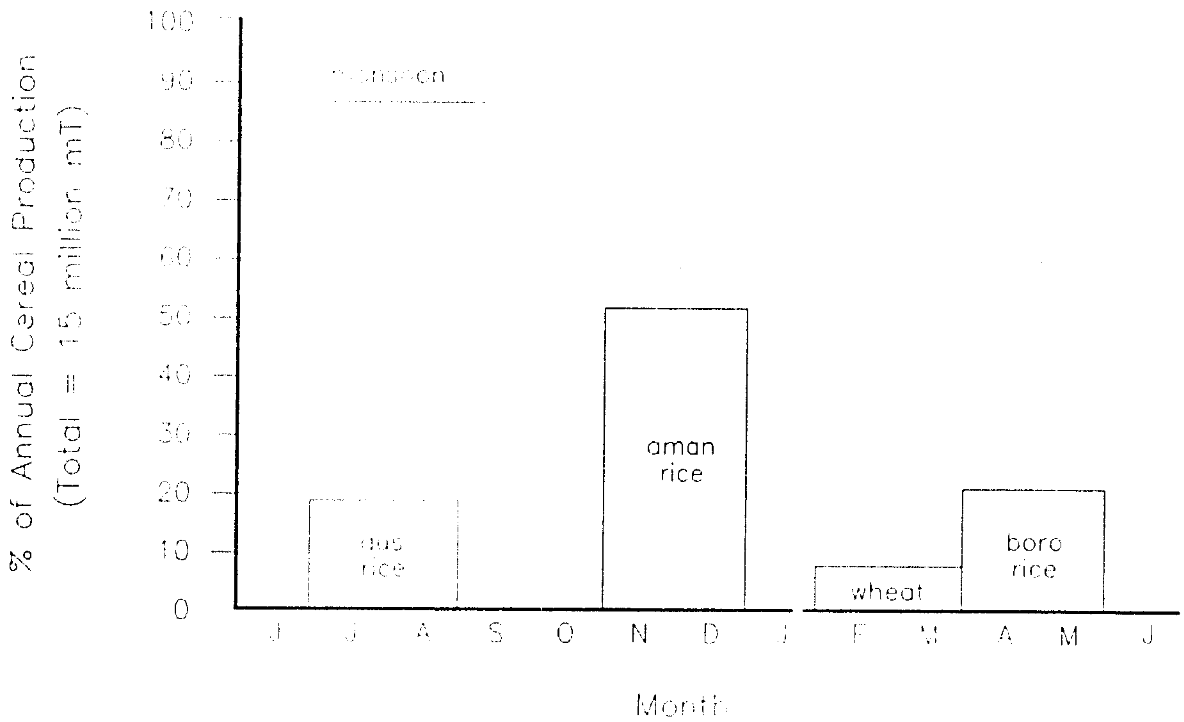


Fig. 2. Harvest times and relative production of major cereal crops in Bangladesh.

The annual trend in rat burrow numbers in the fields is shown in Figure 3. Trends from both study sites are similar. The seasonal peak in rat numbers is in November and December, coincident with the aman rice harvest. During the two aman rice crops sampled, rat burrow numbers peaked at about 18/ha. The lower number at Mirzapur in 1987 was probably due to the unusually high flood which preceded this aman crop. Burrows are assumed to be predominantly those of the lesser bandicoot rat (Bandicota bengalensis) and usually contain a single adult rat.

The numbers of rat burrows generally decline between January and July, being only about 3/ha at the onset of the rains in July. Numbers remain very low through the floods (July-September) and begin to recover in October, when breeding presumably is high. During the period of decline, secondary and tertiary peaks occur coincident with the wheat and boro rice harvest, respectively. No tertiary peak occurred at Ishurdi where the boro crop was relatively insignificant. Sharp declines in the numbers of burrows following each peak may be the result of rats remaining in their burrows and feeding on stored grain. Cover is minimal following harvest and plowing, suggesting that predation may be an important factor in regulating the numbers of B. bengalensis in Bangladesh where farmlands are intensively cultivated and cover is sparse.

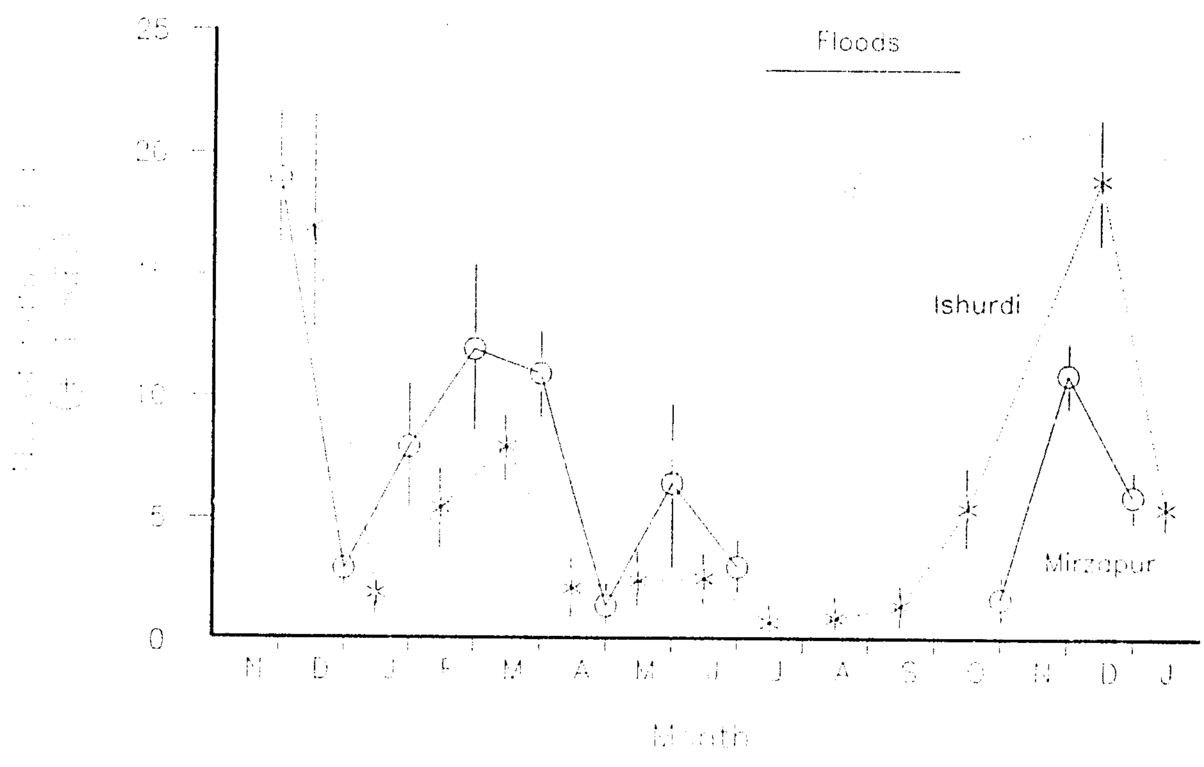
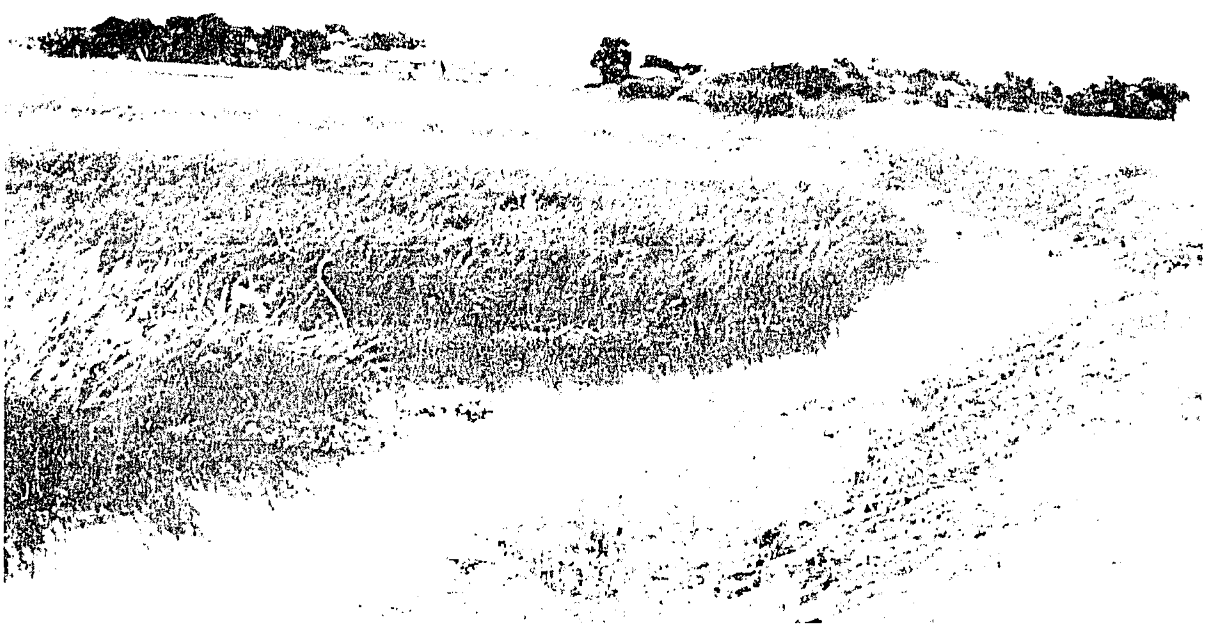


Fig. 3. Seasonal pattern in the overall numbers of active rat burrow systems per hectare sampled at Ishurdi and Mirzapur, Bangladesh.

To determine what this seasonal pattern in the fluctuation of *B. bengalensis* means in terms of a control strategy, it is necessary to know in which of the four cereal crops (Fig. 2) there is the greatest concentration of rat burrows, and in relation to this crop, when and where the best opportunities for control exist to keep numbers low. The seasonal concentration of rat burrows in rice is highest at about 25 rats/ha in aman rice compared with only about 9 rats/ha in boro rice and negligible numbers in aus rice (Fig. 4). Since most rice production occurs in the aman season, the greatest potential for damage is during the aman harvest. The loss associated with each burrow system is about 1.7 kg in rice and 1.5 kg in wheat (Fig. 5), representing roughly 40-50 kg/ha of rice in the study sites. These trends suggest that control efforts be focused in rice in October as the floods recede and the numbers of rat burrows begin their sharp increase.



Deepwater rice in booting stage in Bangladesh.

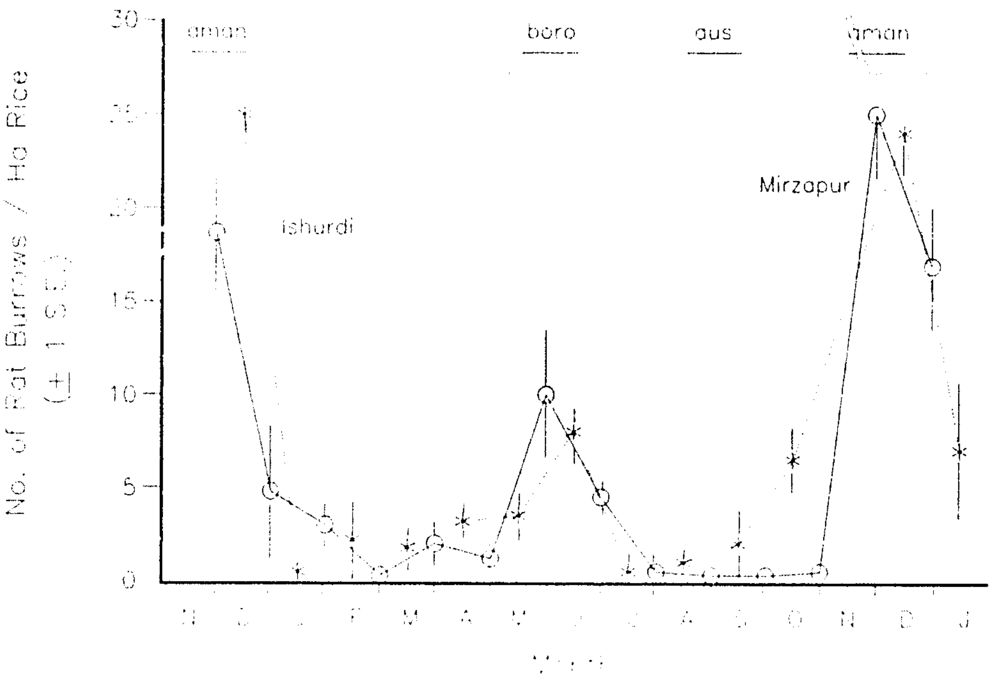


Fig. 4. Seasonal pattern in the numbers of active rat burrow systems per hectare of rice sampled at Ishurdi and Mirzapur, Bangladesh.

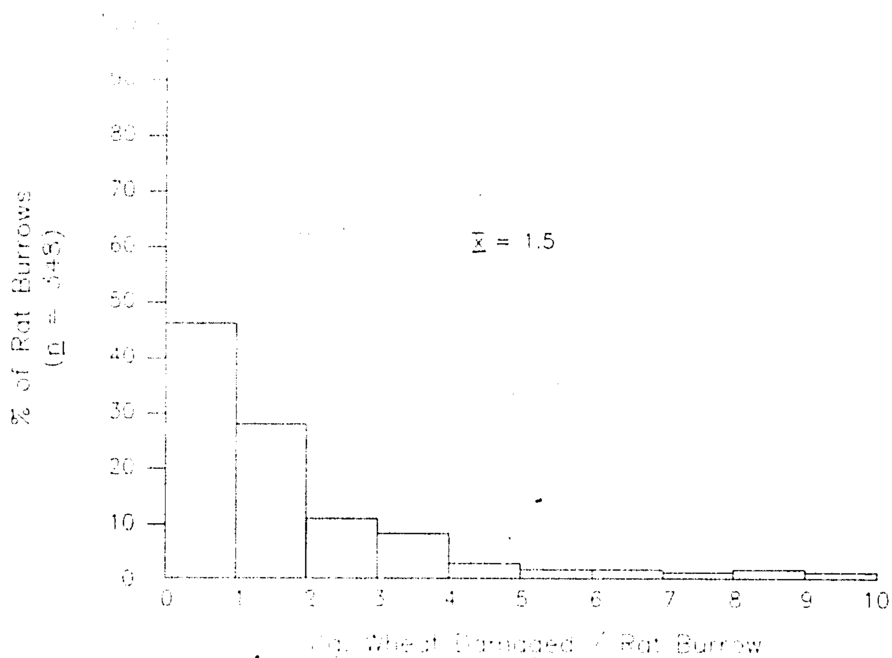


Fig. 5. Frequency distribution of damage levels around individual rat burrow systems in wheat estimated at Ishurdi and Mirzapur, Bangladesh.

The numbers of rat burrows per hectare of wheat are illustrated in Figure 6. As with rice, the numbers peak at the time of harvest. At Ishurdi, the numbers of rat burrows were less than half the numbers at Mirzapur. This difference between study sites may have been due to unseasonally dry conditions at Ishurdi. Losses at Mirzapur were approximately 97 kg/ha of wheat (57 rats/ha x 1.7 kg/rat) compared with 28 kg/ha of wheat (25 rats/ha x 1.1 kg/rat) at Ishurdi. There was substantially less area of cultivated wheat at either study site than of aman rice, as suggested by Figure 2, so that the estimated damage was greatest for aman rice, followed by wheat and boro rice (Fig. 7).

Bandicoot burrow system with stored wheat in Bangladesh.

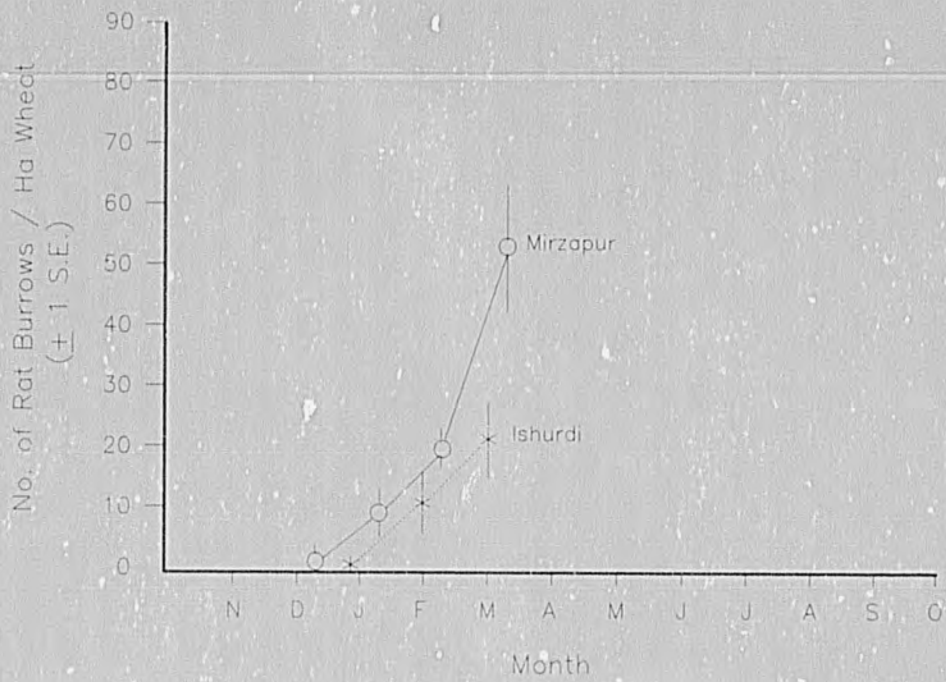


Fig. 6. Seasonal pattern in the numbers of active rat burrow systems per hectare of wheat sampled at Ishurdi and Mirzapur, Bangladesh.

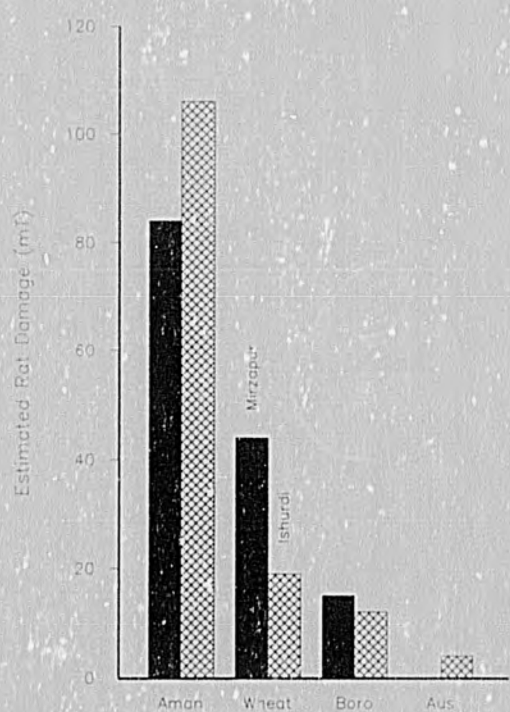


Fig. 7. Comparison of estimated rat damage in each of the four major cereal growing seasons at the 4,800-ha sampling sites at Ishurdi and Mirzapur, Bangladesh.

Rat burrows are first concentrated in pulse/mustard before wheat matures and offers either sufficient cover or a source of grain (Fig. 8). Therefore, one strategy for reducing rat damage in wheat could be to control the rats in these adjacent fields of pulses and mustard before they are harvested and the rats move out to invade the wheat. Both crops are cultivated in small fields, averaging 0.05 ha in the study areas, and intermixed with fields of other crop types, including early stages of boro rice. Attempting to control rats only in wheat fields using poison baits may be ineffective as most rats invade the wheat when ripening grain is available; wheat is probably preferred to baits as a food. Effective rat control in pulses and mustard is also likely to reduce rat numbers in the succeeding boro rice crop.

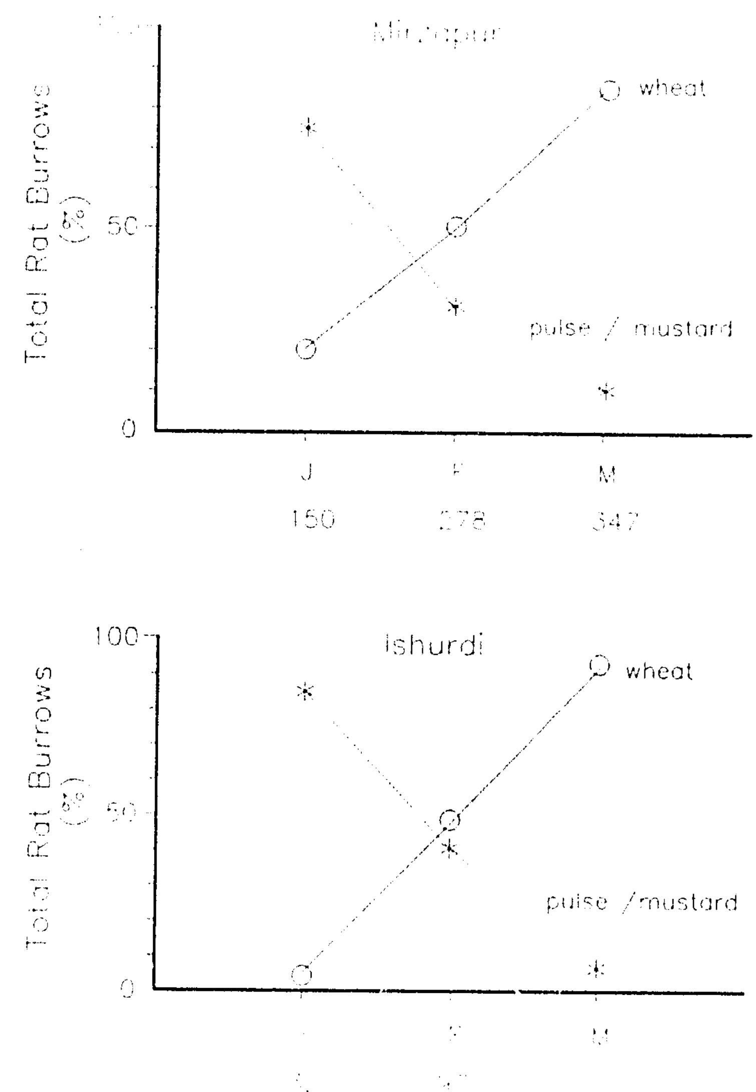
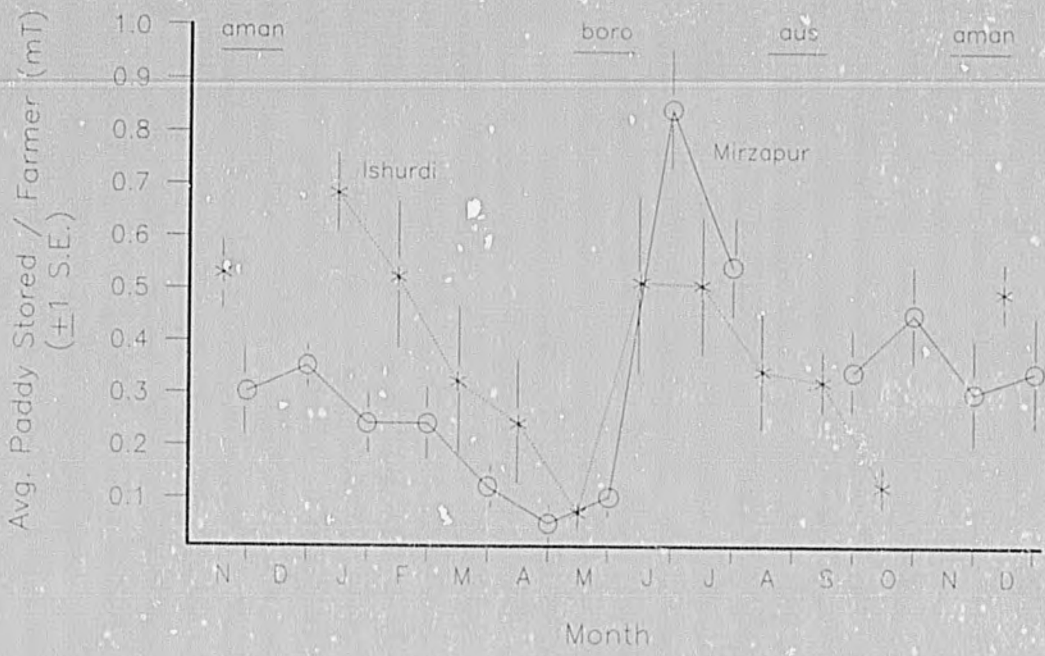


Fig. 8. Monthly change in the numbers of active rat burrow systems in wheat and pulse/mustard at Ishurdi and Mirzapur, Bangladesh. This illustrates that rats concentrate in each crop and move from pulse/mustard to wheat following harvest.

Postharvest Rodent Surveys in Farmers' Houses

Rodent damage surveys were conducted in farmers' houses to determine the seasonal patterns of grain storage and of rodent numbers to be able to predict when and where control might be most beneficial. Stored rice was present in farm houses throughout much of the year (Fig. 9); however, a seasonal pattern was evident whereby peaks in storage occurred in June-July (boro harvest) and December-January (aman harvest). At Ishurdi, stores were highly variable but were the lowest in April-May and in October. The same pattern occurred for the percent of farmers with stored grain each month (Fig. 10). The number of bandicoot burrow systems in houses (Fig. 11) follows the same seasonal trends described above for the stored grain, suggesting that B. bengalensis is attracted to stored food which it caches in its burrow systems. Trap success was lowest for bandicoot rats, followed by roof rats (Rattus rattus), musk shrews (Suncus murinus), and house mice (Mus musculus) (Fig. 12). However, differences in trapability, trap types, and trap positions within houses must be accounted for in estimating numbers. A seasonal trend in trap success was evident only for M. musculus (Fig. 13). The highest percent of captures was associated with the monsoon, suggesting that house mouse damage is greatest relative to the storage of the boro crop.

Grain storage containers are stored on several levels and are subject to rodent damage in Bangladesh households.



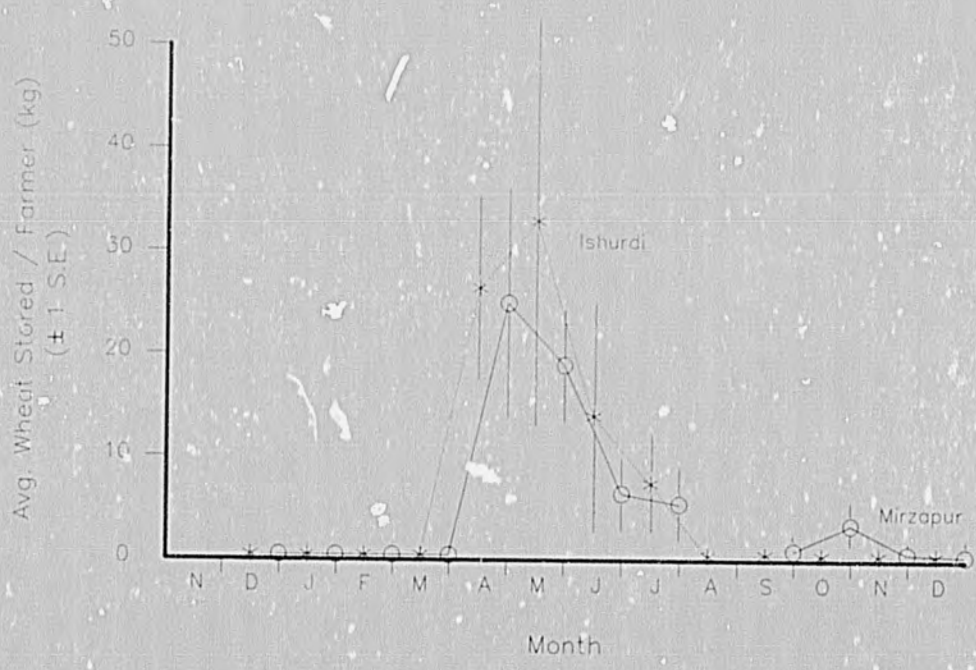


Fig. 9. Seasonal pattern in amount of paddy rice and wheat stored in farmers' houses at Ishurdi and Mirzapur, Bangladesh.

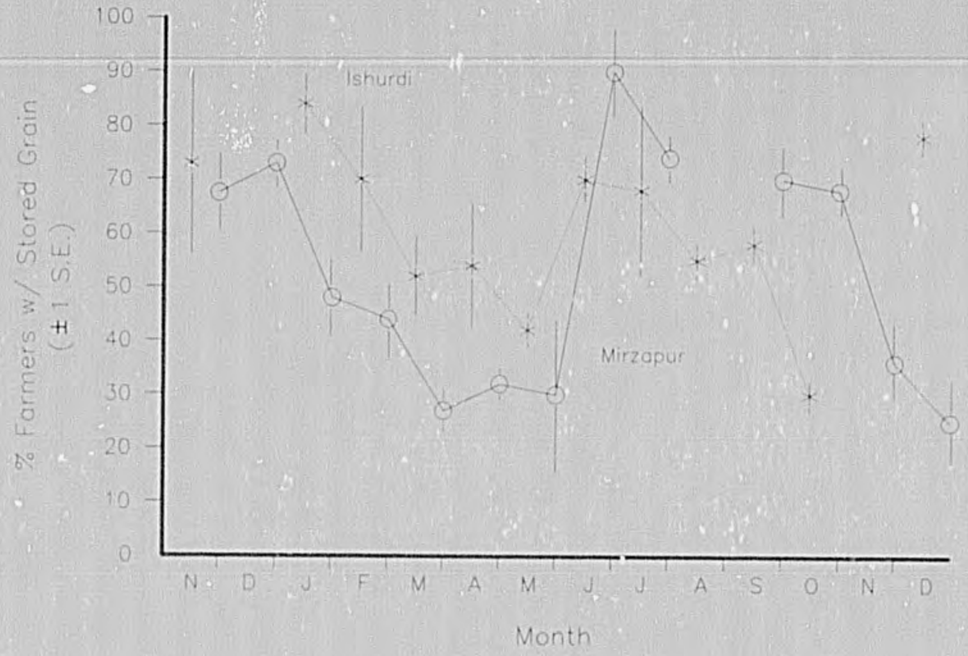


Fig. 10. Seasonal pattern in the percent of farmers with stored grain from Ishurdi and Mirzapur, Bangladesh.

Fig. 11. Seasonal pattern in the numbers of active rat burrow systems in farmers' houses at Ishurdi and Mirzapur, Bangladesh.

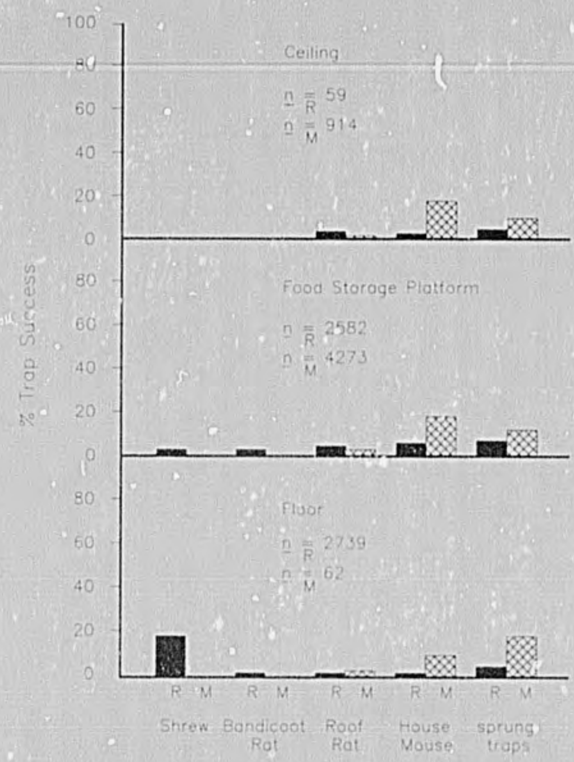


Fig. 12. Percent trap success and species composition of small mammals from farmers' houses at Ishurdi and Mirzapur, Bangladesh.

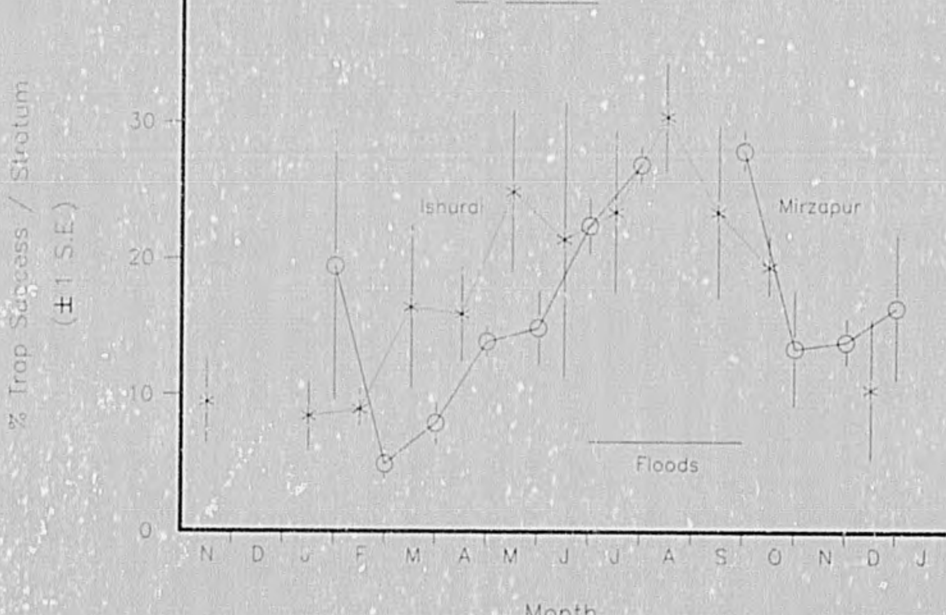


Fig. 13. Seasonal pattern in the percent trap success of house mice (<u>Mus musculus</u>) in farm houses at Ishurdi and Mirzapur, Bangladesh.

Jackal Studies

Jackal Predation of Rodents. Rodents are the most serious vertebrate pest of agriculture in Bangladesh, and jackals, while themselves a pest of poultry, may be beneficial in terms of rodent control. Therefore, the diet of jackals was sampled to determine the importance of rodents. Rodent bones or teeth were found in about 60% of the 657 scats collected and were the most commonly encountered prey item (Fig. 14). About 30% of all scats had the remains of more than one rodent, with the greatest number being six (Fig. 15). Rats remains occurred more frequently in scats than those of mice, with the most common species, based on tooth patterns, being the *R. rattus* and *B. bengalensis* (Fig. 16). Species differed between the two study sites, with *R. rattus* being more common from Ishurdi where sugarcane was plentiful and *B. bengalensis* more common from Mirzapur where rice, wheat, and pulse predominated. Feathers, mostly from chickens, were the second most common prey item being found in about 30% of the scats (Fig. 14). This may have been due more to eating chicken offal from refuse heaps rather than to actual predation. The percent occurrence of different food items was very similar in both study areas suggesting that this is the general pattern. No clear seasonal trends were evident, due in part to the difficulty of finding scats during the floods, when the numbers of field rats appear to be at their seasonal low (Fig. 3) and when their occurrence in scats would be expected to drop.

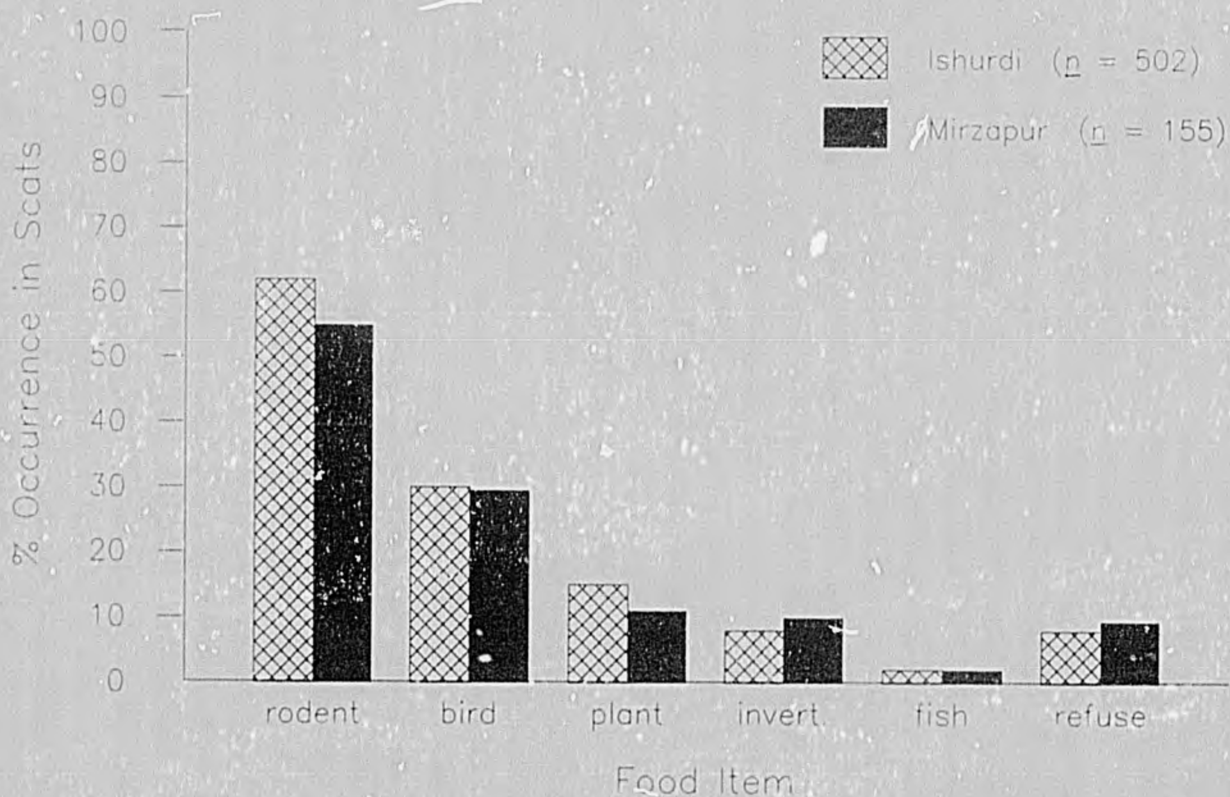


Fig. 14. Percent occurrence of different food items in the scats of jackals sampled at Ishurdi and Mirzapur, Bangladesh.

Jackals have been reported by many farmers to be pests to livestock, melons, sugarcane, and corn in Bangladesh.

Fig. 15. Frequency distribution of rodent numbers per jackal scat sampled at Ishurdi and Mirzapur, Bangladesh.

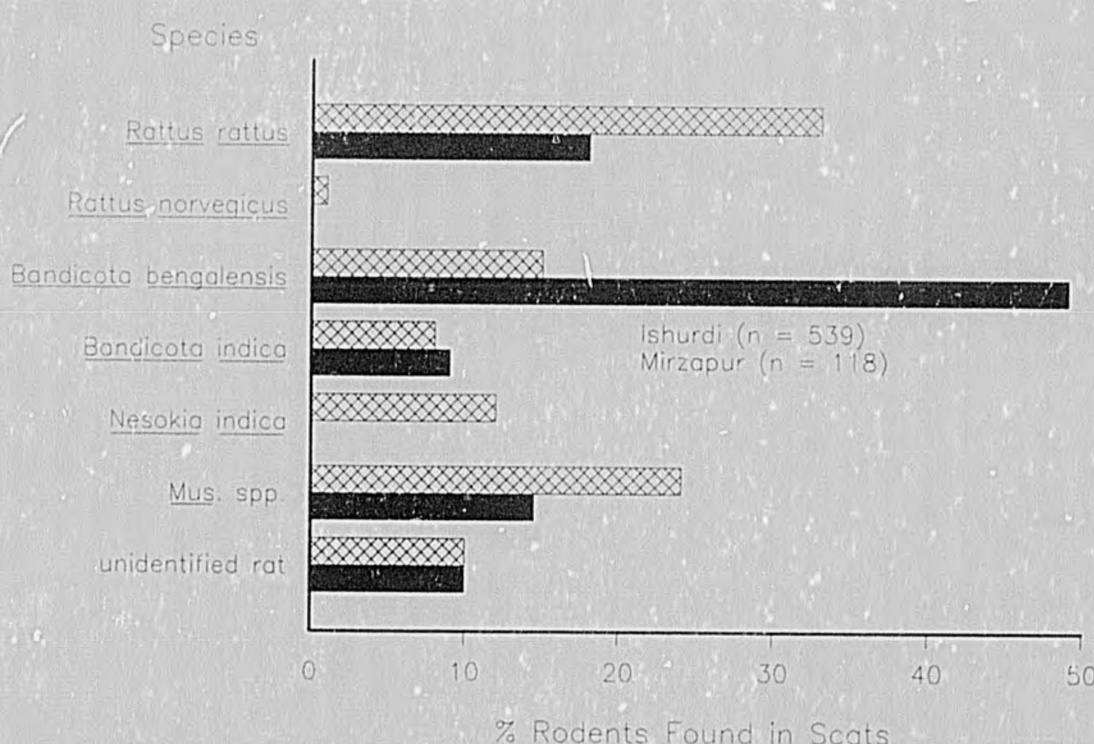


Fig. 16. Rodent species identified in jackal scats from Ishurdi and Mirzapur, Bangladesh.

Several observations suggest that vegetational cover (from predators) is a determinant of the type and seasonal abundance of rats found in fields. For example:

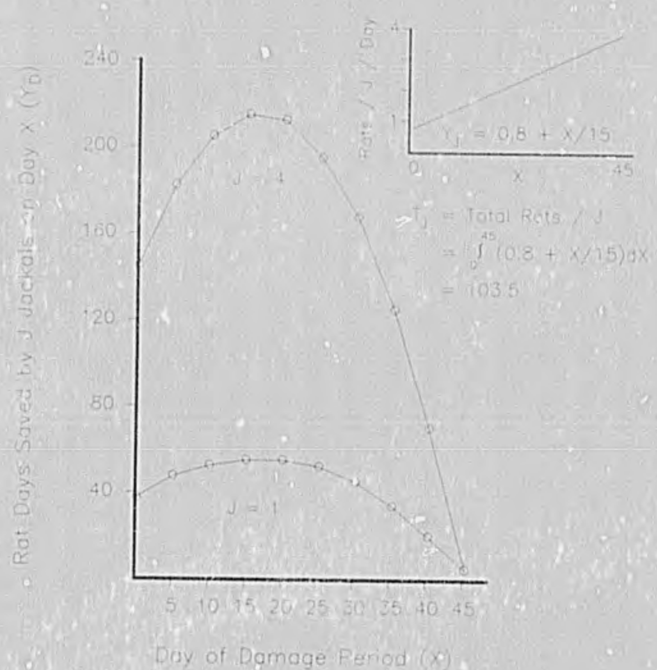
1. the predominant species of rats (Bandicota spp. and Nesokia indica) found in rice and wheat fields live in underground burrows and are nocturnal. This is probably because permanent (long-standing) cover is scarce around cropping areas, as these areas are intensively cultivated throughout the year;

2. the seasonal pattern in fluctuation of the numbers of rat burrows reflects the seasonal pattern of day length with the greatest number of rats occurring when nights are the longest in winter and the fewest when nights are shortest in summer; and

3. following harvest of the aman and boro rice crops and wheat (and, therefore, the removal of cover), the numbers of rat burrow systems drop sharply, suggesting that rats can remain underground until cached food is exhausted.

Nesokia indica burrows along field borders in Bangladesh.

It is difficult to evaluate the impact of solely jackals on rodent numbers as a variety of other predators, including mammals, birds, and reptiles also occurs. However, it is possible to make predictions on the potential impact of jackal predation on rat damage to a particular crop in which rats are concentrated, as for example in ripening wheat. A simple model of how jackal predation could theoretically reduce rat damage to wheat is presented in Figure 17. Calculations are based on a typical 1-km^2 block where 15% of the area (15 ha) is cultivated in wheat. The graph with the accompanying equation shows that a single jackal can destroy 103.5 rats in the wheat over the 45-day period of rat damage, from tillering to harvest, by increasing its daily intake from an average of less than 1 to 4 rats. By referring to Figures 6 and 8, which show the increasing concentration of rat burrow systems in wheat as the crop matures, it is clear that the impact of predation on damage changes with the number of rats consumed per day and the remaining time to harvest, so that the greatest impact is between days 15 and 20. The total number of rat days saved per jackal in this model would be 1,823, representing 127.6 kg of wheat, assuming a rat destroys 70 g per day. This amount is 12% of the estimated rat damage in wheat when the numbers of rats per hectare of wheat increase from 15 to 30 over the damage period (Fig. 18).



$Y_D = J(0.8 + X/15)(45 - X)$

$Y_D = J(36 + 2.2X - X^2/15)$

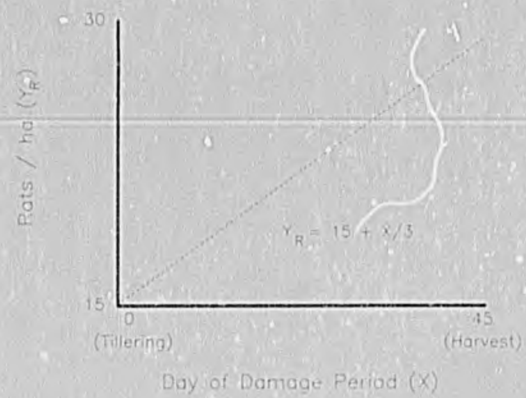
T_D = Total Number Rat Days Saved

$= \int_0^{45} J(36 + 2.2X - X^2/15)dX = 1822.5\ J$

T_S = Total Amount Wheat Saved

$= (1822.5)(70\ \text{gm/rat/day})\ J = 127.6\ \text{kg}\ J$

Fig. 17. Model of the potential impact on rat damage of jackal predation on rats concentrated in wheat in Bangladesh.



Assume 15 ha wheat / 1-km^2

Then $15\ Y_R = 225 + 5X$

T_R = Number of Rat Days in Wheat

$$= \int_0^{45} (225 + 5X)dX$$

$$= 15187.5$$

Assume each rat removes 70 gm wheat / day

Then total loss in 1-km^2 is 1063.1 kg

Fig. 18. Model of rat damage in wheat in Bangladesh.

Jackal Daytime Cover. The occurrence of suitable cover probably influences the distribution and numbers of jackals as well as other terrestrial predators of rodents in Bangladesh. Knowledge of the cover used by jackals may be beneficial to (1) understanding the factors that influence jackal mortality; (2) determining opportunities for selective control of jackals when necessary; (3) determining home range; and (4) developing a practical method for censusing.

The daytime cover and movements of ten radio-equipped jackals (five males and five females) were studied in six separate sites at Ishurdi. Seven of these animals were located in at least 5 successive months, and three were located for 11 months. Jackals were tracked in sugarcane in over 80% of the 131 observations (Fig. 19). Sugarcane was used exclusively from December through February, and other types of cover were used after this period, as the harvest of sugarcane neared completion. The planting and harvest of sugarcane near Ishurdi was staggered throughout the year.

Based on the scat collections (Fig. 14), jackals appeared to be more numerous at Ishurdi, where sugarcane was relatively abundant, than Mirzapur. Sugarcane also provided cover and a source of food for *R. rattus*, which was the most common rodent species found in the scats of jackals from Ishurdi (Fig. 16). Jackals may be able to hunt *R. rattus* during the day in sugarcane, as this rat species commonly hides above ground.

Fig. 19. Types of daytime cover used by jackals at Ishurdi, Bangladesh, as determined by radiotelemetry.

Jackals apparently became more vulnerable to humans as the sugarcane harvest neared completion. Female 10 was killed in March, and her mate, Male 2, was later poisoned (Fig. 20). The average distances from their original points of capture to daytime cover increased in April-May (1,051 m) compared to December-January (486 m) or February-March (343 m; $\underline{F} = 5.15$, $\underline{P} < 0.05$) suggesting that cover was harder to find. Furthermore, females normally gave birth between February and April. Dens in sugarcane were exposed during harvest, and dens found in ditch embankments were destroyed by farmers.

There are several possible implications of cover to the management of jackals in Bangladesh. First, the spatial and temporal distribution of sugarcane is probably an important determinant of local jackal densities and, as such, may be a means by which to regulate their numbers. Second, where jackals are determined to be an overall benefit, that is, for rodent control, their numbers may be increased by the staggered presence of sugarcane. Third, where jackals are determined to be an overall detriment (for example, where they prey on poultry or livestock), their numbers may be reduced by limiting the amount of sugarcane, synchronizing its harvest, or destroying jackals in sugarcane during the harvest when they are most concentrated.

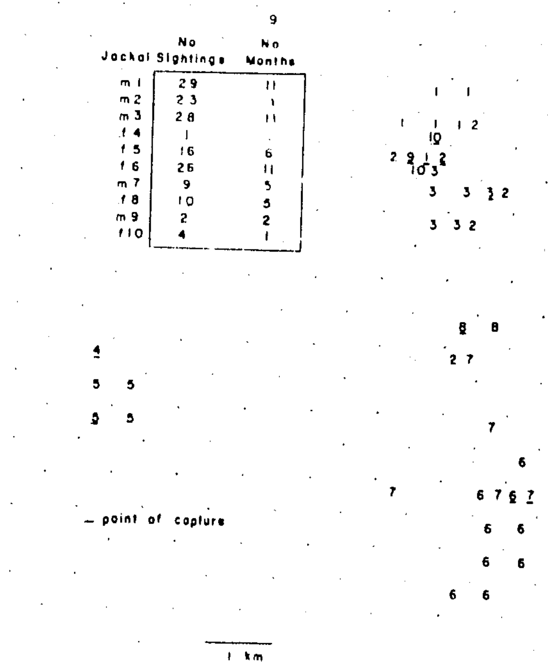
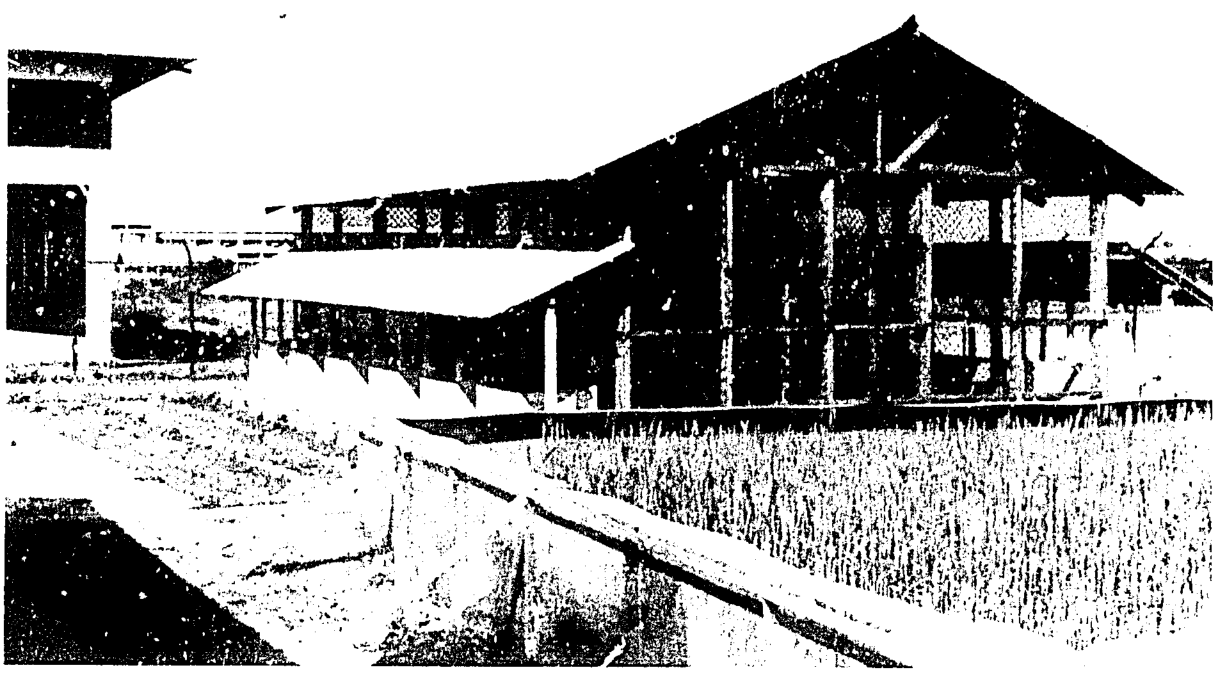


Fig. 20. Range of daytime cover of individual jackals at Ishurdi, Bangladesh, as determined by radiotelemetry.



Rodent exclosure and jackal pen at Vertebrate Pest Control Laboratory, BARI, Bangladesh.

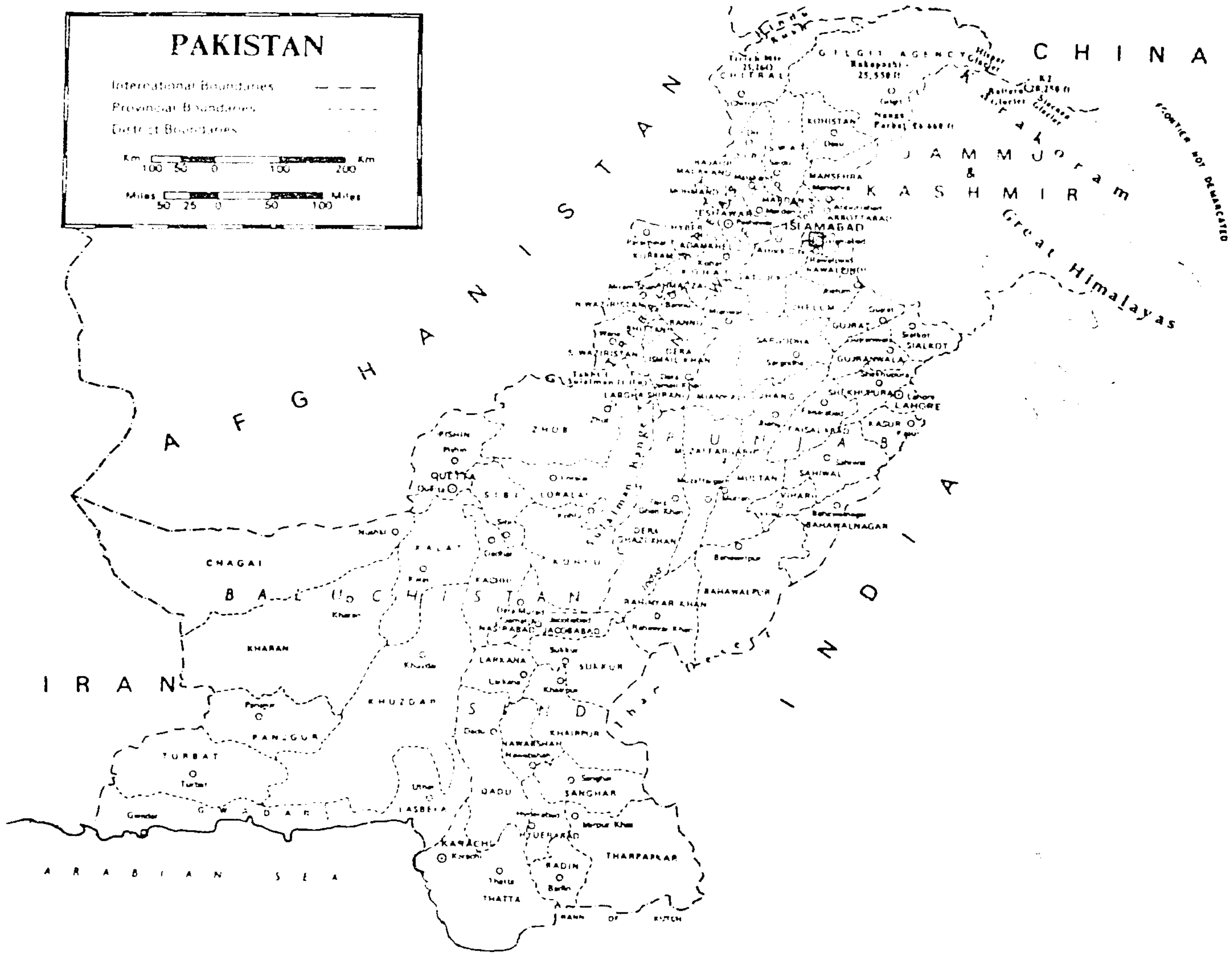
Censusing Jackals. Jackals have not yet been systematically censused in different habitat types in Bangladesh such as a sugarcane-growing area. Estimates of jackal densities are needed to predict their potential for either damage or rat control. Evidence suggests that densities can be high. The range used for daytime cover can be an area of only about 1 km^2 (Fig. 20; Jackals 1, 3, 5, and 8), and this area is even smaller when cover is stable, that is, before sugarcane harvest. In addition, jackals can be concentrated where suitable cover occurs, for example, at the end of the sugarcane harvest. For instance, 13 jackals were seen between dusk and dark one evening in an area of less than 1 km^2 in partially harvested sugarcane. In a similar area nearby, at least 10 jackals responded to a taped jackal call.

Jackals usually were seen or heard as singles or in pairs. Of 63 sightings or vocal responses recorded near Ishurdi between November 1986 and October 1987, 29 were of single jackals, 30 of pairs, and 4 of triplets. Radio tracking suggested that paired animals could be of the same sex. For example, Males 1 and 2 and Males 2 and 3 (Fig. 20) were occasionally found together. This may be an adaptation to capturing fossorial rats that have extensive burrow systems with more than a single opening. A censusing technique is now being developed to take advantage of the jackals' use of sugarcane for daytime cover and their response to taped calls. Preliminary tests of the technique elicited responses from instrumented animals in sugarcane from seven of nine times. Further testing is being done with improved amplification of the taped calls.

Personnel and Training

Mr. Rajat Pandit finished his studies on an M.S. degree at the University of the Philippines at Los Banos and returned to the VPRL. Mr. Emdadul Haque continued his postgraduate studies at Dhaka University. His research topic is "The biology, agricultural importance, and control of the short-tailed mole rat, *Nesokia indica*, in Bangladesh."

Individuals from the U.S. Department of State, USAID/Dhaka, and the Bangladesh Agricultural Research Institute are being briefed by the project leader and BARI scientists on vertebrate pest research activities at the Vertebrate Pest Control Laboratory in Bangladesh.


PAKISTAN
International Boundaries
Provincial Boundaries
District Boundaries
Km 100 50 0 100 200 Km
Miles 50 25 0 50 100 Miles
CHINA
AFGHANISTAN
IRAN
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JAMMU & KASHMIR
Great Himalayas
Karakoram
GILGIT AGENCY
CHITRAL
ISLAMABAD
PUNJAB
BALUCHISTAN
SIND
QUETTA
LAHORE
KARACHI
CHAGAI
KHARAN
TURBAT
PANJGUR
KHUZDAR
GWADAR
ZHOB
SIBI
LARKANA
SUKKUR
KHAIRPUR
DADU
SANGHAR
HYDERABAD
THARPARKAR
BADIN
THATTA
BAHAWALPUR
BAHAWALNAGAR
SAHIWAL
MULTAN
SIALKOT
ARABIAN SEA
RANN OF KUTCH

PAKISTAN

Introduction

The Vertebrate Pest Control Project (VPCP) was initiated in March 1985 under the Government of Pakistan and USAID Post-harvest Management Component of the Food Security Management Project. The objectives of the VPCP are:

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

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

3. improve the quality of adaptive research programs for stored grains;

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

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

Since 1985, it has been found that preharvest losses of grains and other crops were equal to or even more significant than losses in storage facilities. Accordingly, the Joint Secretary for Food in the Ministry of Food, Agriculture, and Cooperatives asked USAID for assistance and recommended that the VPCP also work on preharvest problems, particularly those with which farmers find it hardest to cope. This added another objective to the program:

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

During 1987, the VPCP staff started a 1-year study of the reproductive biology of the roof rat (Rattus rattus) and also of rat population densities in wholesale grain markets at Rawalpindi, Faisalabad, and Lahore. Average daily consumption of wheat and rice by bandicoot and roof rats was checked, and experiments to determine the comparative toxicities of three anticoagulants for roof rats were performed. Preliminary control trials of different anticoagulants for wild boar control were done at Fateh Jhang. Field studies were carried out on the campus of National Agricultural Research Centre (NARC) to control different vertebrate pests, mainly rodent pests in experimental crops. The VPCP staff conducted seven courses in vertebrate pest management training to farmers, extension workers, and scientists.

Wheat and Rice Consumption by Bandicoot and Roof Rats

Mean daily consumption of wheat and rice by the lesser bandicoot rat and roof rat was determined. Daily wheat consumption by *B. bengalensis* and *R. rattus* averaged 14.7 g and 17.9 g, respectively; daily rice consumption averaged 14.4 g and 12.7 g, respectively (Table 1).

Table 1. Wheat and rice consumption (g) by *Bandicota bengalensis* and *Rattus rattus*.

Days	Wheat		Rice	
	Bandicoot rat	Roof rat	Bandicoot rat	Roof rat
1	8.7	17.5	17.2	12.1
2	14.3	11.7	15.7	14.9
3	13.6	15.3	17.1	13.5
4	15.6	20.7	14.7	14.2
5	15.6	20.7	14.7	14.2
6	15.6	20.7	14.7	14.2
7	16.3	17.6	14.4	12.5
8	15.6	19.0	8.6	10.1
9	17.3	18.6	12.9	10.1
10	14.4	16.9	14.4	11.5
Avg.	14.7	17.9	14.4	12.7

Rodent Control at PARC Building and in the Parliament Chambers

The VPCP was informed of rodent infestations in the new building of the Pakistan Agricultural Research Council. Live traps were set in nine areas, and six roof rats were captured during a 22-day period. At the request of Mr. Muhammad Rafiq Abbasi, Deputy Director, Maintenance Division (Civil), Parliament Building, the Parliament Buildings also were inspected for rat problems. Evidence of roof rat infestations were seen in the canteen and restaurant kitchens and in the pantry area of the Prime Minister's Chambers. Problems with house mice gnawing on electrical cables were found in the Computer and Communication Center of the National Assembly. A control program was not conducted because of difficulties in obtaining security passes.

Comparative Toxicities of Three Anticoagulants to *Rattus rattus*

The comparative toxicities of brodifacoum, bromadiolone, and coumatetralyl (Racumin^R) to *R. rattus* from Rawalpindi were studied in the laboratory on individually caged groups of rats (3 males, 3 females). Rats were offered the anticoagulants at concentrations ranging from 0.625 to 80 parts per million (ppm) for 4 nights only in no-choice tests using broken rice bait as the base. Mortality was noted for up to 20 days from the start of the test (Table 2). A value for the 4-day LC_{50} (lethal concentration that kills 50% of the test animals after 4 days of feeding) was estimated from the mortality data using probit analysis. The 4-day LD_{50} can be estimated in the same way from the mean amounts of active ingredient (a.i.) consumed by each test group (Table 3). The 4-day LD_{50}'s were 0.41 mg/kg, 0.51 mg/kg, and 4.40 mg/kg, respectively. The 4-day LD_{50} values indicate that R. rattus are reasonably susceptible to the three anticoagulants tested and that the usual recommended field concentration of each active ingredient is more than enough to give complete mortality in ≤4 days of feeding.

Table 2. Mortality of *Rattus rattus* when fed anticoagulants in no-choice tests for 4 days.

Anticoagulant concentration (ppm)	Mortality No. dead/tested	Dose of a.i. consumed (mg/kg) Mean	Min. to kill	Max. survived	Mean day of death
Brodifacoum					
0.625	2/6	0.12	0.13	0.15	25
1.25	1/6	0.26	0.28	0.34	15
2.5	2/6	0.57	0.56	0.68	23
5.0	6/6	1.4	1.06	-	7
10.0	8/8	3.2	2.64	-	7
20.0	6/6	6.0	3.50	-	6
40.0	6/6	9.6	4.70	-	7
Bromadiolone					
0.625	1/6	0.13	0.14	0.17	28
1.25	2/6	0.27	0.20	0.39	22
2.5	2/6	0.61	0.42	0.93	16
5.0	5/6	1.4	1.05	1.12	7
10.0	5/6	3.3	2.71	-	9
20.0	6/6	5.4	4.53	-	8
40.0	6/6	11.7	10.60	-	10
Coumatetralyl					
5.0	1/6	1.2	0.89	1.86	4
10.0	2/6	3.0	3.00	3.36	24
20.0	5/12	4.5	2.48	7.34	8
40.0	4/6	8.3	4.62	11.84	10
80.0	6/6	12.2	8.00	-	10

Table 3. Four-day LC_{50}'s (ppm) and 4-day LD_{50}'s (mg/kg) of three anticoagulant rodenticides to Rattus rattus.

Rodenticide	LC_{50} (ppm)	95% C.L.	LD_{50} (mg/kg)	95% C.L.
Brodifacoum	1.8	0.9- 3.1	0.41	0.19-0.75
Bromadiolone	2.1	1.1- 3.7	0.51	0.24-0.94
Coumatetralyl	19.6	9.8-38.3	4.40	2.30-7.80

Wild Boar Control at Fateh Jhang

Studies to determine wild boar (Sus scrofa) damage to crops and to devise control methods were initiated in the area of Jinder, Fateh Jhang, under Farming Systems Research (MART Project). During a 2-day trial in a forest plantation near Jinder, warfarin was tested as a poison. Seven bait stations were established in an area of approximately 2 km. All possible sites of wild boar movements were surveyed with the help of a local farmer. Wheat flour, 0.05% warfarin, and 2% molasses (an attractant) were then mixed into about 100-g dough balls. Each bait ball was coated with 100% powdered cream and placed in appropriate locations. Uneaten balls were retrieved the next morning before sunrise. Signs of wild boar and carcasses were recorded daily after baiting.

During a second bait evaluation near Jinder, 14 sites were selected in a 2.5-km area. In these trials, 0.025% warfarin was used for the first 3 days until the supply was exhausted, and 0.025% coumatetralyl was used throughout the remainder of the campaign. After the 4th day of baiting, each site was checked by three to six persons for 10 days to locate dead boar. Animals began to die the 8th day of the second baiting session, and by the end of the study, 29 dead animals (17 wild boar, 6 porcupines, 6 jackals) had been located. No dead birds (raptors or scavengers) were found. During the 15-day baiting period, peak bait consumption occurred on the 7th day and was reduced to 33% of this amount by the last day of baiting (Fig. 21).

During the study, 7,774 out of 9,395 bait balls were eaten. The approximate cost of the trial for labor, bait materials, and poisons was Rs 3,600 or the equivalent of about US $205. The results indicate that wild boar readily take anticoagulant baits over a period of several weeks and are susceptible to its effects. However, a bait delivery system needs to be developed to avoid killing nontarget jackals and porcupines.

Wild boar (Sus scrofa) often destroy large portions of groundnut fields in a single night and cause extreme losses to farmers in Pakistan.

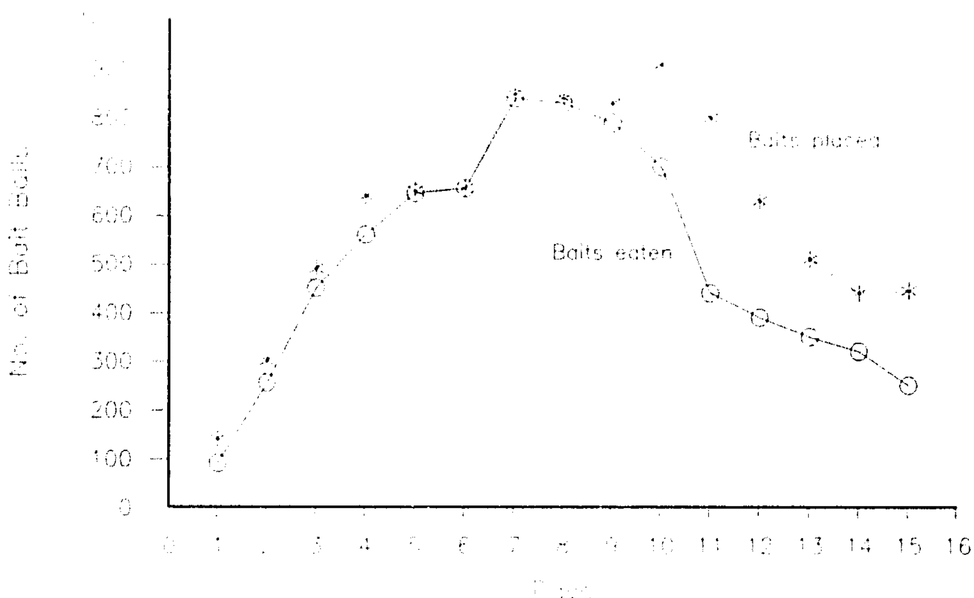


Fig. 21. Number of wild boar baits placed and eaten near Jinder, Fateh Jhang, Pakistan.

Rat Populations in Wholesale Grain Markets

Rodent populations were compared in grain storage markets in Rawalpindi, Faisalabad, and Lahore during 1987. Studies of the rodent population in the wholesale grain market, Raja Bazar, Rawalpindi, were initiated in January and April 1987. To determine the rat activity, 20 tracking tiles (10 off floor, 10 on floor) were placed in each of eight shops and observed the next morning. The next day, 8 live traps and 16 kill traps (8 rat, 8 mouse) were baited and placed in each shop. After 1 day, the number of traps was changed to 10 live traps and 5 kill traps to improve mouse trapping success. This number was used throughout the rest of the study. After 6 days, 20 tracking tiles again were put out to determine if there was any reduction in activity. The results of this initial study are given in Table 4.

Only roof rats were captured. Their original pretrapping population was estimated in two ways: (1) from the change-in-ratio (CIR) of activity on the trapping tiles and the known number of animals captured and (2) the decline in catch per unit effort (Fig. 22). The estimate from the CIR method was 297 rats in the eight shops when trapping began. The estimate from the decline in catch per unit effort was 355 rats. The two estimates define the limits of rat populations in the shops and give an average number of rats per grain shop of 37 to 44. This number of roof rats would be expected to eat slightly more than 0.5 kg of rice per night per shop, or 200 kg per shop per year.

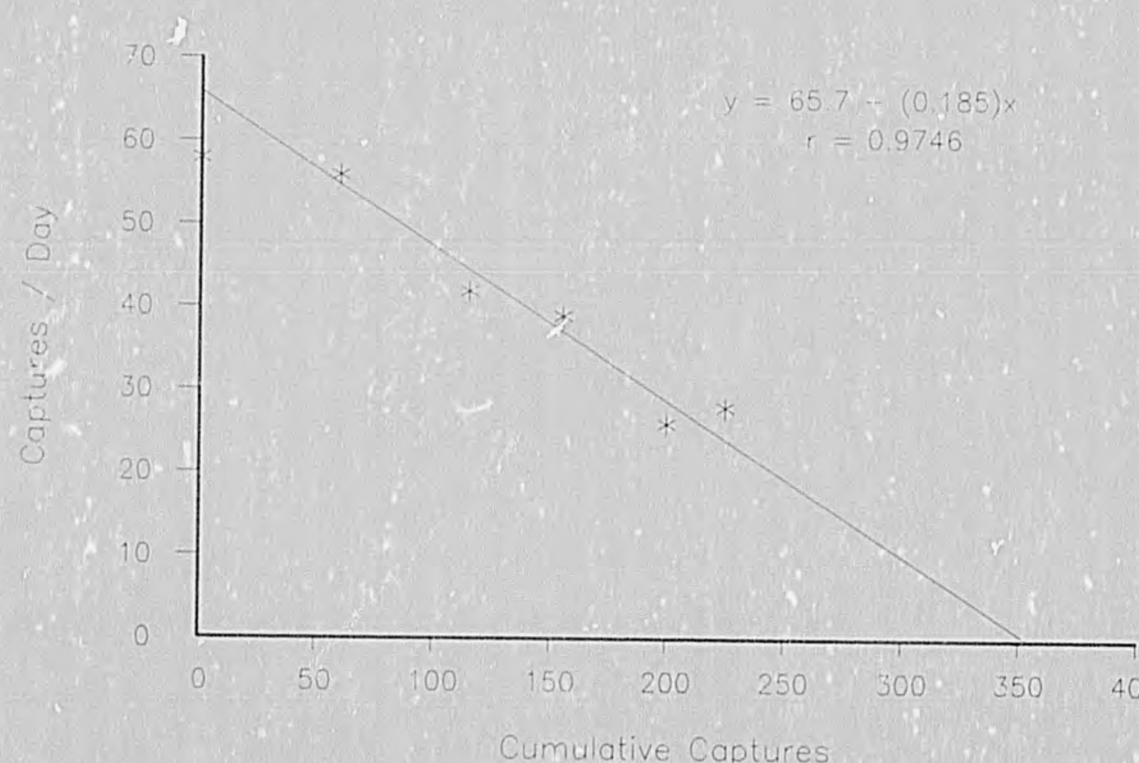


Fig. 22. Estimate of rat population in grain market, Rawalpindi, Pakistan, during January 1987.

Table 4. Rat population studies in grain market, Rawalpindi, Pakistan, during January 1987.

Shop No.	Pretrapping % positive tiles	No. rats trapped, Days: 1	2	3	4	5	6	Total	Posttrapping % positive tiles	Estimated population: CIR	Lin. reg.
1	82	10	10	7	9	8	7	51	20		
2	95	9	8	8	-[a]	5	4	34	25		$y = 65.7-$
3	95	6	6	6	9	1	3	31	5		$(0.185)x$
4	95	8	6	5	8	0	1	28	25		
5	45	8	5	1	1	0	1	16	5	$N_1 = \frac{n \times T_1}{T_1 - T_2}$	$r = 0.975$
6	80	9	5	3	-[a]	0	1	18	15		
7	100	7	9	3	0	0	0	19	5		
8	59	2	7	8	7	12	10	46	17		
Mean/total	81	59	56	41	34	26	27	243	15	297	355

[a] Shops were closed.

The tracking tile activity and animal captures for the April trapping are given in Table 5. A total of 481 rats was taken in 735 effective trap nights. Immature rats accounted for 16% of the sample. Capture per shops ranged from 30-76 rats and averaged 60 rats. Again, as in January, trap catch declined as expected in some shops, but changed very little in others.

Because tracking tile activity after the end of 6 nights of removal trapping had not changed, an additional 4 nights of removal trapping was completed to obtain a valid CIR population estimate. After 10 days, the tracking tile activity was reduced 21.7% from 86.6% to 67.8% positive.

The estimated pretrapping rat population in the eight shops in April, as calculated by the CIR method, would have been 2,217 rats in the eight shops. Based on the removal of 481 rats, this is probably not a realistic estimate. The population estimate derived from the CAPTURE computer program gave a probably more realistic estimate of 785 rats (95% C.L. = 591-979) (Fig. 23).

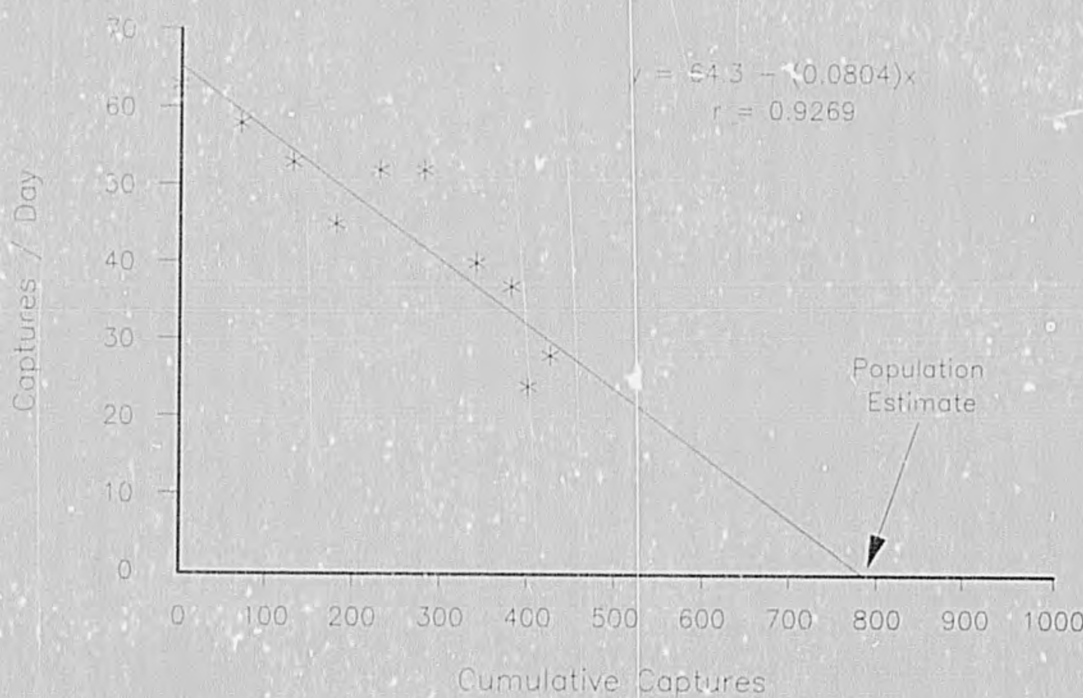


Fig. 23. Estimate of rat population in grain market, Rawalpindi, Pakistan, during April 1987.

Table 5. Rat population studies in grain market, Rawalpindi, Pakistan, during April 1987.

Shop No.	Pretrapping % positive tiles	No. rats trapped — Days 1	2	3	4	5	6	7	8	9	10	Total	Posttrapping % positive tiles	Estimated population CIR	Lin. reg.
1	100.0	7	8	5	4	5	7	6	4	6	8	60	100.0		
2	100.0	6	1	6	0	6	6	3	2	0	0	30	100.0		
3	95.0	4	10	11	7	7	10	8	9	3	7	76	35.0		$y = 64.3 - (0.0804)x$
4	90.0	9	11	9	7	6	8	6	5	7	7	75	55.0		
5	100.0	9	7	5	7	6	5	5	7	3	9	63	100.0		
6	20.0	8	2	4	6	6	2	6	4	2	1	41	0.0	$N_1 = \frac{n \times T_1}{T_1 - T_2}$	$r = 0.975$
7	95.0	10	10	4	5	8	7	6	11	7	5	73	70.0		
8	80.0	10	10	9	9	7	6	8	4	0	0	63	100.0		
Mean/total	86.6	63	59	53	45	51	51	48	46	28	37	481	67.8	2,217	785

The wholesale grain market at Faisalabad is one of the biggest grain markets in the Punjab with more than 300 grain dealers who handle a variety of commodities, including wheat, rice, pulses, groundnut, and cotton. To determine rodent populations in this market and Karkhana Bazar, we selected eight shops in each site and used similar trapping and tracking tile techniques as in Rawalpindi. The trapping results from both sites are given in Table 6 (Figs. 24 and 25).

A combined total of 116 rats were trapped from 16 shops in 12 nights of trapping at both sites. Again, roof rats were the only species trapped. Of 116 rats, 60 were male and 56 were female. Forty-one percent of females were pregnant, and 75% of the males were sexually mature. Males were mature sexually at 140- to 149-mm head and body lengths. The population was reduced 93.4% in the wholesale grain market after 8 nights of trapping and 42.3% in Karkhana Bazar after 5 nights.

The pregnancy rate of rat populations in Rawalpindi and Faisalabad was almost the same. The percent of sexually mature males was greater in Rawalpindi (95.7%) than in Faisalabad (75%).

The difference in rat density between Faisalabad grain market and Karkhana Bazar is related to the wholesale grain market shops being comparatively new construction and occupied for only 6 or 7 years. In contrast, the shops in Karkhana Bazar are more than 40 years old. Secondly, some shopkeepers in the wholesale grain market try to keep their shops clean and control rodents, while many shops in Karkhana Bazar are untidy and deteriorating.

The situation of the Akbari Mandi market in Lahore was different from that of Faisalabad, but it was similar to the Rawalpindi wholesale grain market. Shops having various commodities, i.e., wheat, rice, pulses, groundnut, dry fruit, spices, etc., were present in the same street. As in Rawalpindi and Faisalabad, tracking tiles and traps were set to obtain rodent population density data. Reduction in rodent activity was 46.7% after 8 nights of trapping and removal of these animals. The rat density in Lahore was comparable to that determined for Rawalpindi (40-100 rats per shop) and considerably greater than at either wholesale market in Faisalabad (5-6 per shop) or the Karkhana Bazar (20-25 rats per shop).

In Lahore three species were collected: roof rats, house mice, and shrews. A total of 234 animals was trapped, which included 229 rats, 4 mice, and 1 shrew (Table 7; Fig. 26). Out of 229 rats, 112 were males and 117 were females. Eighty-three percent of the males were sexually mature, and 21.4% of the females were pregnant.

A detailed technical report summarizing these grain market studies in the Punjab is being prepared.

Table 6. Rat population studies in wholesale grain market and Karkhana Bazar, Faisalabad, Pakistan.[a]

Shop No.	Pretrapping % positive tiles	No. rats trapped: Days 1	2	3	4	5	6	7	Total	Posttrapping % positive tiles	Estimated population: CIR	Lin. reg.
Wholesale grain market												
1	90	3	1	1	0	0	0	0	5	0		
2	100	7	2	1	2	2	0	0	14	10		y = 17.61-
3	35	2	0	1	0	0	1	0	4	10		(0.46)x
4	80	3	1	0	0	0	0	0	4	0		
5	89	4	0	0	0	0	0	0	4	0		r = 0.931
6	63	0	0	0	0	1	0	0	1	0	$N_i = \frac{n \times T_1}{T_1 - T_2}$	
7	50	1	0	2	1	2	0	0	6	16		
8	100	0	0	0	1	0	0	0	1	0		
Mean/total	76	20	4	5	4	5	1	0	39	5	42	38
Karkhana Bazar												
1	0	0	0	0	0	0			0	0		
2	100	5	9	4	6	3			27	55		y = 20.52-
3	85	4	0	0	0	2			6	61		(0.1454)x
4	95	5	2	5	2	2			16	65		
5	10	2	1	1	3	0			7	20		r = 0.853
6	25	2	2	0	3	3			10	37	$N_1 = \frac{n \times T_1}{T_1 - T_2}$	
7	80	2	2	2	2	1			9	0		
8	20	2	0	0	0	0			2	0		
Mean/total	52	22	16	12	16	11			77	30	182	141

[a] No trapping was done at Karkhana Bazar on days 6 and 7.

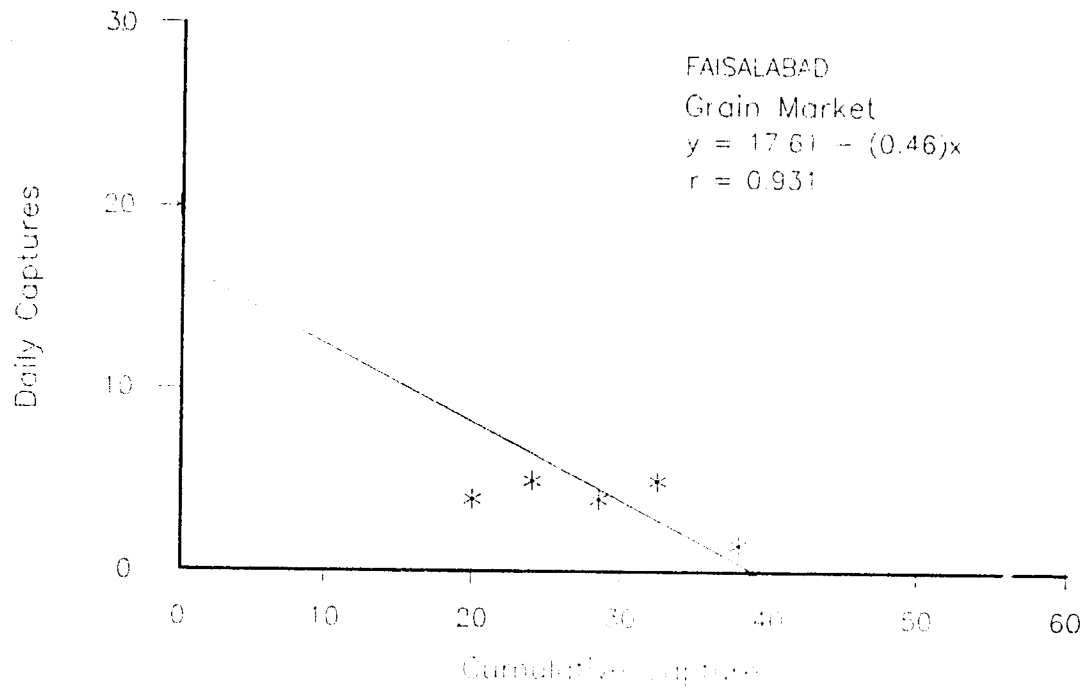


Fig. 24. Estimate of roof rat population in grain market, Faisalabad, Pakistan.

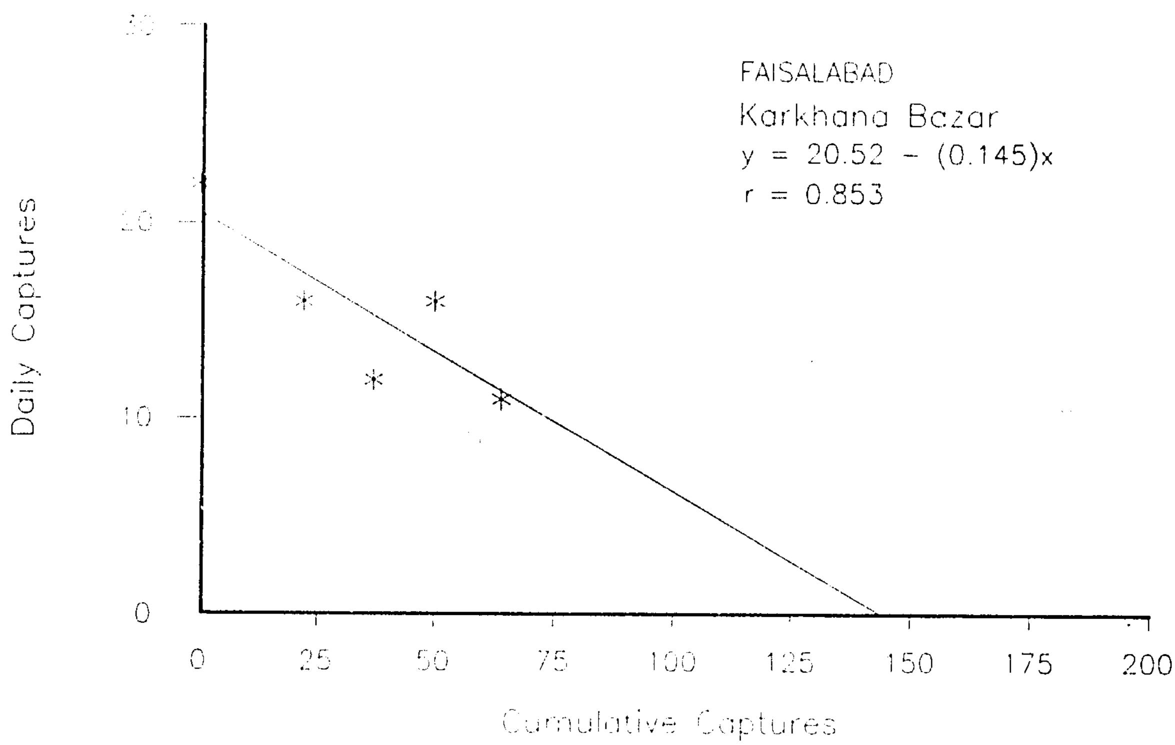


Fig. 25. Estimate of roof rat population at Karkhana Bazar, Faisalabad, Pakistan.

Table 7. Rat population studies in Akbari Mandi, Lahore, Pakistan, during January 1987.

Shop No.	Pretrapping % positive tiles	No. rats trapped: Days 1	2	3	4	5	6	7	8	Total	Posttrapping % positive tiles	Estimated population: CIR	Lin. reg.
1	100	9	6	7	2	5	8	0	5	42	0		
2	100	4	9	7	8	4	1	0	0	33	80		$y = 40.04 -$
3	100	7	2	1	6	4	4	6	4	34	30		$(0.092)x$
4	11	2	2	1	3	1	0	0	2	11	30		
5	10	6	2	0	4	1	3	0	2	18	12		$r = 0.765$
6	90	12	2	0	4	3	3	0	3	27	15	$N_1 = \frac{n \times T_1}{T_1 - T_2}$	
7	100	-	5	7	8	3	7	5	3	38	70		
8	88	-	6	6	3	5	7	1	3	31	84		
Mean/total	75	40	34	29	38	26	33	12	22	234	40	501	435

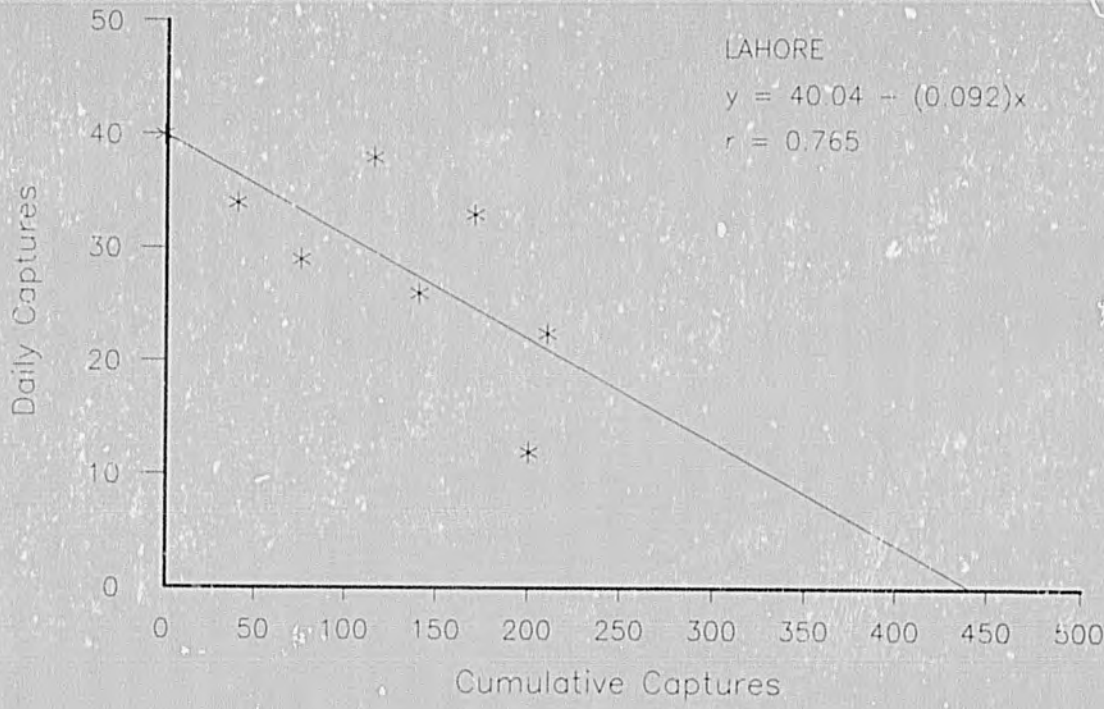


Fig. 26. Estimate of rat population at Akbari Mandi, Lahore, Pakistan.

Reproductive Biology of *Rattus rattus* in a Wholesale Grain Market

A 1-year study of the reproductive biology of the roof rat was initiated in April 1987. The study is being conducted to better understand the population dynamics of this important pest of stored foods in Pakistan. Preliminary trapping data indicated that *R. rattus* populations are high in the small grain shops characterizing the wholesale market and that their reproductive rates may also be higher than previously reported. Summary data on the size at sexual maturity (50% points) of both males and females, pregnancy rates in adult females, and litter sizes are given in Tables 8, 9, and 10.

Table 8. Body length and weight of *Rattus rattus* when 50% of males have visible tubules in the cauda epididymis and 50% of females have visible corpora lutea in the ovaries.

	Males		Females	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)
Visible tubules in cauda epididymis	152	96	-	-
Visible corpora lutea	-	-	139	-

Table 9. Visible pregnancy in adult ($\geq$140 mm body length) female *Rattus rattus* from a wholesale grain market at Rawalpindi, Pakistan.

Month	No. adult females examined	No. visibly pregnant	% pregnant
Apr	139	52	37.4
May	57	27	47.4
Jun	74	26	35.1
Jul	83	46	55.4
Aug	66	20	30.3
Sep	95	37	38.9
Oct	63	19	30.2
Nov	58	26	44.8
Dec	83	39	47.0
Total	718	292	

Table 10. Litter size in *Rattus rattus* (n = 292) trapped in Rawalpindi, Pakistan.[a]

No. embryos	Frequency
1	2
2	6
3	8
4	22
5	51
6	53
7	71
8	30
9	28
10	13
11	7
12	1

[a] Mean = 6.53 ± 1.98 (SD).

Cooperative Research Studies

1. Cooperative research studies were continued under Dr. Mirza A. Beg, Department of Zoology, University of Agriculture, Faisalabad, on rose-ringed parakeets, rodents in crop and noncrop areas and in stored food, primarily as part of degree programs for graduate students. Thesis abstracts are summarized.

   a. Breeding Habits and Nest Density of Rose-ringed Parakeet by Mohammad Sarwar, M.Phil. Degree in Zoology, University of Agriculture, Faisalabad, 1987.

   Cavities in trees are the predominant nesting sites of rose-ringed parakeets. Parakeets compete for these sites with common mynas, palm squirrels, spotted owlets, Indian roller, and several species of reptiles. Copulating birds were seen from mid-January until mid-April. Only females incubated the eggs; males foraged for food and fed the females. Young were seen being fed between late April and July 11. Of 20 active nests, only 35% fledged young. Reasons for the failure of the 13 nests were not known.

   The predominant tree species in the study area was *Dalbergia sissoo* (Table 11), but it only supported 12 parakeet nests. The most important tree species, in terms of parakeet use and abundance, were *Acacia arabica* (46 nests) and *Albizzia* spp. (10 nests). *Albizzia* spp. were rare but were heavily utilized by parakeets.

Table 11. Relative abundance of tree species in Faisalabad District, Pakistan, and use by parakeets and other animals.

Tree species	No. seen	No. tree cavities	No. occupied by parakeets	No. occupied by other animals
Dalbergia sissoo	2,001	107	12	12
Acacia arabica	861	238	46	8
Azadirachta indica	141	1	0	0
Mangifera indica	99	23	1	1
Morus spp.	73	15	2	2
Terminalia arjuna	53	39	5	4
Tamarix aphylla	31	33	3	3
Albizzia spp.	25	35	10	2
Cordia myxa	13	6	3	2
Salmalia malabarica	16	18	5	3
Salvadora oleoides	7	21	0	8
Erythrina suberosa	6	4	2	1
	3,331	540	89	46

b. Foraging and Feeding Behaviour of Rose-ringed Parakeet by Abdul Karim, for M.Phil. Degree in Zoology, University of Agriculture, Faisalabad.

Parakeets have two well-defined periods during which most of their feeding and foraging activities are confined: the first 3 h after sunrise and the last 3 h before sunset. During the rest of the day, most of the parakeets stay in roosts.

The feeding niche of the parakeet is fairly broad. It feeds on as many as 37 plant species. However, parakeets depend heavily on agricultural crops, particularly sunflower, mustard, maize, sweet peas, wheat, sorghum, and orchard fruits for their food (Table 12).

Table 12. Plants fed upon by rose-ringed parakeets in Faisalabad District, Pakistan.[a]

Plant	Portion eaten	Season			
		Fall	Winter	Spring	Summer
Terminalia arjuna	Fruit	-	-	F	-
Ficus bengalensis	Fruit	-	I	F	-
Zizyphus spp.	Fruit	-	I	F	-
Psidium guajava	Fruit	F	-	-	I
Mangifera indica	Fruit	-	-	F	F
Morus spp.	Fruit	-	-	I	-
Capsicum spp.	Fruit	F	-	-	-
Brassica spp.	Pods	-	I	R	-
Cicer arietinum	Pods	-	-	F	-
Cyanopsis psoralioides	Pods	F	-	-	-
Prosopis juliflora	Pods	-	-	F	R
Phaseolus aureus	Pods	R	I	-	-
Raphanus sativus	Pods	-	-	F	-
Abizzia spp.	Pods	-	I	F	-
Lathyrus spp.	Pods	I	I	-	-
Cassia fistula	Seed	-	-	I	I
Melia azedarach	Seed	F	F	F	-
Linum usitatissimum	Seed	-	-	F	-
Zea mays	Seed	I	-	-	I
Sorghum vulgare	Seed	I	I	-	-
Helianthus annuus	Seed	-	I	I	I
Triticum aestivum	Seed	-	-	F	-
Erythrina suberosa	Flower	-	-	I	-
Tagetes spp.	Flower	-	-	F	-
Saccharum officinarum	Pulp	-	F	-	-

[a] R = rare; F = frequent; I = intensive

c. Rodent Species and Burrow Densities in Crop Fields by Muhammad Ubaidullah for M.Sc. Degree in Zoology, University of Agriculture, Faisalabad.

Studies on rodent species and burrow system density in 52 ha of wheat and 28 ha of rice fields in central Punjab showed an average number of burrows of 25 and 38/ha, respectively. *Bandicota bengalensis* was the predominant species in both wheat and rice fields, averaging 13 and 30/ha, respectively. The Indian gerbil (*Tatera indica*) and the soft-furred field rat (*Rattus meltada*) were other important rodent species.

Lesser bandicoot rat burrows were found under 16% of 746 sheaves of harvested wheat. Of 20 excavated bandicoot burrow systems, 16 had cached wheat panicles. An average of 152 g of wheat grain was stored as food in and around a bandicoot burrow.

d. Rodent Species and Burrow Densities in Noncrop Areas, by Muhammad Anwar for M.Sc. Degree in Zoology, University of Agriculture, Faisalabad.

A study on rodents and burrow densities in 38 ha of embankments and 32 ha of noncrop areas showed that rodents preferred embankments ($\bar{x}$ = 43.1 per ha) to noncrop areas ($\bar{x}$ = 17.3 per ha). The short-tailed mole rat, *Nesokia indica*, and the Indian gerbil were the most abundant rodent species.

Farm and Village Stored Food Losses

Six villages were sampled for small mammals between July and December 1987. In 2,610 trap nights, 469 animals of four species were captured. *R. rattus* (n = 287) was the most common species. *M. musculus* (n = 64), *T. indica* (n = 58), and *S. murinus* (n = 60) were also present. The house rat was predominant in human dwellings and in village shops. *T. indica* and *M. musculus* were most abundant in farm houses, while *S. murinus* was most abundant in flour mills and farm houses. House mice were found in all types of structures trapped.

2. Cooperative research also was conducted under Dr. M. Hafeez Khan, University of Agriculture, Faisalabad, on the Biology and Morphometrics of Wild Boar.

Seventy-six wild boar were collected during 1987. Morphometric measurements were taken, and reproductive tracts and stomach contents were collected. Eye lenses and lower jaws were removed and preserved for later examination of aging technique (weight of the eye lens, molar irruption, and annular tooth growth rings). Males weighed as much as 135 kg; the largest female weighed 76 kg.

Vertebrate Pest Control at NARC

In mid-January, the Chairman, Pakistan Agricultural Research Council, directed that the VPCP undertake a campaign to reduce rodents on the NARC campus to a level where they are not a problem to field experiments. The campaign strategy for this operation consisted of:

- surveying the entire NARC campus to locate rodent infestations;

- dividing the NARC campus into 12 operational zones;

- recruiting and training field staff in rodent control methods and bait preparation methods;

- controlling rodents through burrow baiting, fumigation, and trapping;

- placing permanent PVC pipe bait stations in areas of chronic rodent infestation and along irrigation canals and drainages;

- rebaiting as required using polythene bait packets;

- surveying the NARC campus at the conclusion of the control campaign to evaluate success; and

- maintaining control once lower rodent populations are achieved.

Three different poisons (zinc phosphide, Racumin[R], and bromadiolone) and a fumigant (Phostoxin[R]) were used during this control operation. Cake baits and loose grain baits were applied in the burrows. In some areas permanent bait stations and bait packets were also applied. In addition, various types of traps were used to kill rodents in experimental and fallow fields, ditches, and waste areas.

Between January and mid-May, the end of the campaign, the campus was treated three times. During the first treatment, 10,419 rodent burrows were treated, and during the final treatment, 1,313 burrows were treated, a reduction of 87.4% (Fig. 27). The cost of the campaign was Rs 7,900.00, or about the equivalent of U.S. $0.75/ha. After the campaign, 1,612 to 3,381 burrows were baited monthly between June and December to maintain low rodent populations.

Fig. 27. Average number of rodent burrows baited per zone at NARC, February-May 1987.

Birds, boar, and desert hare also were damaging experimental plantings on the NARC campus. Crested larks (<u>Galerida cristata</u>) were digging out newly planted sunflower seeds. When sorghum seed treated with 0.5% methiocarb (by seed weight) was placed in the field by the Oilseed Programme staff, damage to sunflower stopped within 48 h. Wild boar damage to experimental fields of the Plant Introduction Programme at NARC was stopped using 1080-treated (0.03%) bait balls of wheat flour mixed with 2% molasses and coated with 100% powdered cream. An information circular on the control program was issued through the NARC Administration. Four dead boar were located on the NARC campus. Desert hare damage to chickpea plants was stopped by using a 90-cm-high chicken mesh fence.

Training

The Project provided 666 man-days of vertebrate pest management training to 361 participants during 1987 (Table 13). Many participants were farmers from the private sector. Food inspectors, provincial agricultural extension workers, and agricultural scientists were given training in post-harvest storage methods. A 246-page training manual was written, compiled, and mimeographed for use in the Vertebrate Pest Management training course given at NARC. A 22-min video cassette on vertebrate pests and their control was prepared by VPCP staff.

The Grain Storage Management Training Course provided practical demonstrations on rodent control in godowns; 30 participants of the Food Department, Rawalpindi, attended. The participants were told about rodents and their habits, techniques for estimating rodent populations, methods of placing bait stations, and use of baits.

The farmers' training courses on Vertebrate Pest Control were organized by the Technology Transfer Unit, NARC, Islamabad. These courses were held at Bara Kahu and Tarlai Rural Development Centres (Markazes) on January 27 and 28, 1987, respectively. Information was provided on vertebrate pest identification, their biology and damage, and on the proper use of control methods in crops, godowns, and poultry farms. The use of cake and loose grain baits, fumigation techniques using Detia Gas Ex-B^R or Phostoxin tablets, and mylar Bird-scaring Reflecting Tapes were demonstrated in the field.

The VPCP, Islamabad, the Vertebrate Pest Control Laboratory, Karachi, and the Training Institute, NARC, sponsored a course on Vertebrate Pest Management, between August 16-September 3, 1987. This course was attended by 20 participants from different provinces of Pakistan, including three students from the FAO Rodent Control Project in Somalia. A Vertebrate Pest Management Training Manual was prepared.

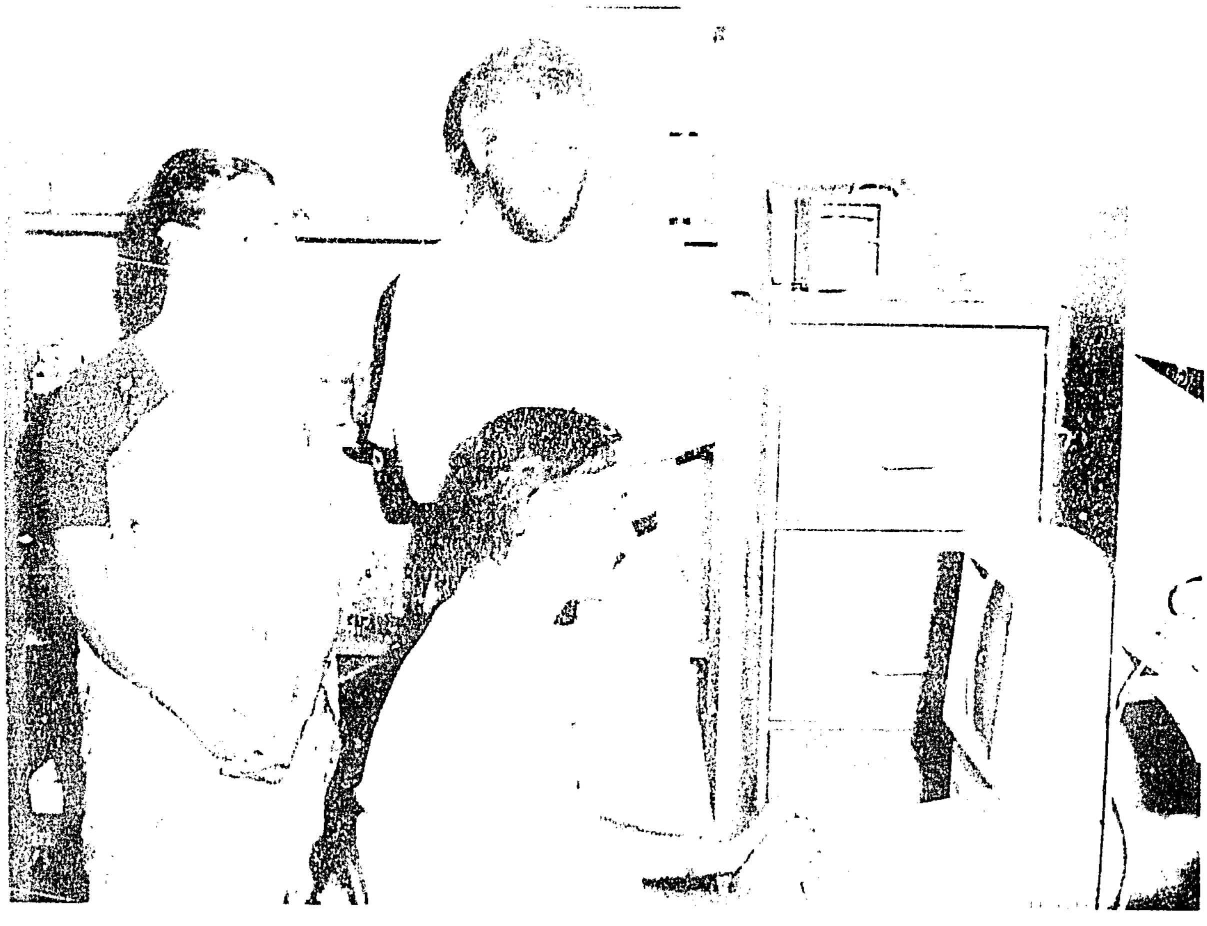
Finally, two lectures on vertebrate pests, their biology, distribution, and management were delivered in the Integrated Pest Management Training Course at NARC from November 22-December 3, 1987. This training course was attended by 20 participants of different research institutes of Pakistan. These lectures are published in the training manual of the course.

Table 13. Training courses, 1987.

Title	Location	Type	Audience	No. participants	Man-days	Duration (days)
Grain Storage Management	Godown of Food Department	Practical demonstration	Food inspectors	30	15	0.5
Farmers' Training	Bara Kahu Rural Centre, Islamabad	Lectures and practical demonstration	Farmers and extension workers	95	95	1.0
Farmers' Training	Tarlai Rural Centre, Islamabad	Lectures and practical demonstration	Farmers	51	51	1.0
Vertebrate Pest Management	NARC, Training Centre	Lectures and practical demonstration	Extension workers and scientists	20	380	19.0
Farmers' Training	Community Centre, Kunjah, Gujrat	Lectures	Farmers	85	85	0.1
Farmers' Training	NARC, Training Centre	Lectures	Farmers	60	30	0.5
Integrated Pest Management	NARC, Training Centre	Lectures	Scientists	20	10	0.5

Staff Training

The VPCP staff received 4 weeks of training in the use of dBase III Plus. This program will be used to construct several databases, primarily one for data from R. rattus captured from grain markets. Messrs. Iftikhar Hussain and Ejaz Ahmad attended the "Short Course in Vertebrate Pest Problems and Solutions in Developing Countries" held on July 20-31, 1987, at Colorado State University, Ft. Collins, Colorado, USA. In addition, Mr. Ahmad spent 7 days studying with scientists and support staff at the Denver Wildlife Research Center, Denver, Colorado. Mr. Liaqat Ali received Executive Secretaries Training from the Pakistan Institute of Management, Karachi, November 28-December 3, 1987.



Research data are being stored on computers for analysis at the Bangladesh and Pakistan field stations.

During 1987, DWRC staff traveled to Asia, the Caribbean, Africa, and Europe at the request of USAID, USAID Missions, USAID/Washington, the Food and Agriculture Organization (FAO) of the United Nations, and foreign governments to assess vertebrate pest problems; to review, evaluate, and coordinate present and future research programs; and to 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 453 person-days in the following countries and islands:

- Antigua
- Bangladesh
- Barbados
- Botswana
- Burkina Faso
- Chad
- Dominica
- Grenada
- Guinea-Bissau
- Italy
- Kenya
- Mali
- Montserrat
- Niger
- Philippines
- Republic of the Maldives
- St. Christopher
- St. Lucia
- St. Vincent
- Senegal
- Sri Lanka
- Sudan

Travel dates, persons involved, countries visited, and the purpose of each trip are outlined briefly in Table 14. Detailed information is contained in individual trip reports on file at IPRS, DWRC.

An important function of IPRS is to provide assistance to many countries and international organizations. During 1987, 189 requests from 57 countries were received and answered. In addition, 2,007 reprints and reports were provided to scientists and pest control specialists worldwide (Table 15).

Table 14. International travel for technical assistance projects by USAID/USDA/APHIS/ADC/DWRC personnel during 1987.

Date	Name	Location	Purpose of trip
Feb 4-Mar 8	R. L. Bruggers	Botswana, Kenya	Assist FAO and MOA personnel in lethal and nonlethal crop protection techniques to control quelea. Conduct training course on quelea survey and control techniques. Draft project proposal for USAID/DWRC technical assistance.
Mar 2-25	G. K. LaVoie	Montserrat	Monitor rodent activity to determine the success of ongoing rodent control activities in urban and agricultural sectors.
Mar 20-Apr 24	R. A. Dolbeer	Sri Lanka, Republic of the Maldives, Italy	Sri Lanka: Review vertebrate pest control project. Maldives: Assess crop damage by bats, rats, crows, and water hens. Develop vertebrate pest control techniques. Train MOA personnel. Italy: Review project with FAO personnel.
Apr 1-21	L. A. Fiedler	Sudan	Assess rodent outbreak. Make short-term, mid-term, and long-term recommendations.
Apr 11-May 1	D. L. Otis	Bangladesh	Provide guidance and recommend sampling techniques and experimental design to be used in evaluating vertebrate pest control strategies.
Apr 11-May 4 Apr 11-May 17	R. L. Bruggers J. B. Bourassa	Niger	Assist MOA and GTZ to determine pest bird movements using fluorescent marking and radiotelemetry techniques. Conduct field trials with Bird-scaring Reflecting Tape.

Table 14 (cont'd)

Date	Name	Location	Purpose of trip
May 9-24 May 27-29 May 30-Jun 6 Jun 6-12	G. K. LaVoie	Chad Senegal Mali Burkina Faso	Assess rodent outbreak and make recommendations for vertebrate pest control and management.
May 10-Jun 10	L. A. Fiedler	Grenada, St. Vincent, St. Lucia, Dominica, Antigua, Barbados, St. Christopher	Define major rodent problems, assess ongoing control methods, and plan training course.
Jul 13-Aug 17	J. O. Keith	Sudan	Assess rodent outbreak and evaluate zinc phosphide control program.
Aug 16-Sep 14	L. A. Fiedler	Sudan, Italy	Follow up on Sudan rodent outbreak. Present paper at the European Plant Protection Organization (EPPO)/FAO Conference, Rome.
Sep 7-11	J. E. Brooks	Rome, Italy	Present paper at the EPPO/FAO Conference.
Sep 17-Oct 11	R. L. Bruggers	Guinea-Bissau	Conduct surveys and identify principal bird pest species in major cropping areas. Assess damage and demonstrate crop protection techniques.
Oct 1-9	L. A. Fiedler	Philippines	Present two papers at the 11th International Congress of Plant Protection, Manila.

Table 14 (cont'd)

Date	Name	Location	Purpose of trip
Oct 10-Nov 10	G. C. Mitchell	Chad	Assess current rodent problem in agriculture. Train agricultural extension agents in rodent control methodology. Conduct experimental evaluations of rodenticides in maturing field crops. Make rodent control recommendations.
Nov 5-24	L. A. Fiedler	Barbados, Grenada	Conduct training course.
Dec 4- Jan 6, 1988	G. K. LaVoie	Republic of the Maldives	Assess success of vertebrate pest control trials previously recommended by DWRC scientists and conducted by MOA personnel. Continue assessment of crop damage and implementation of control methods for bats, rats, crows, and water hens.

Table 15. Requests to DWRC for assistance during 1987.

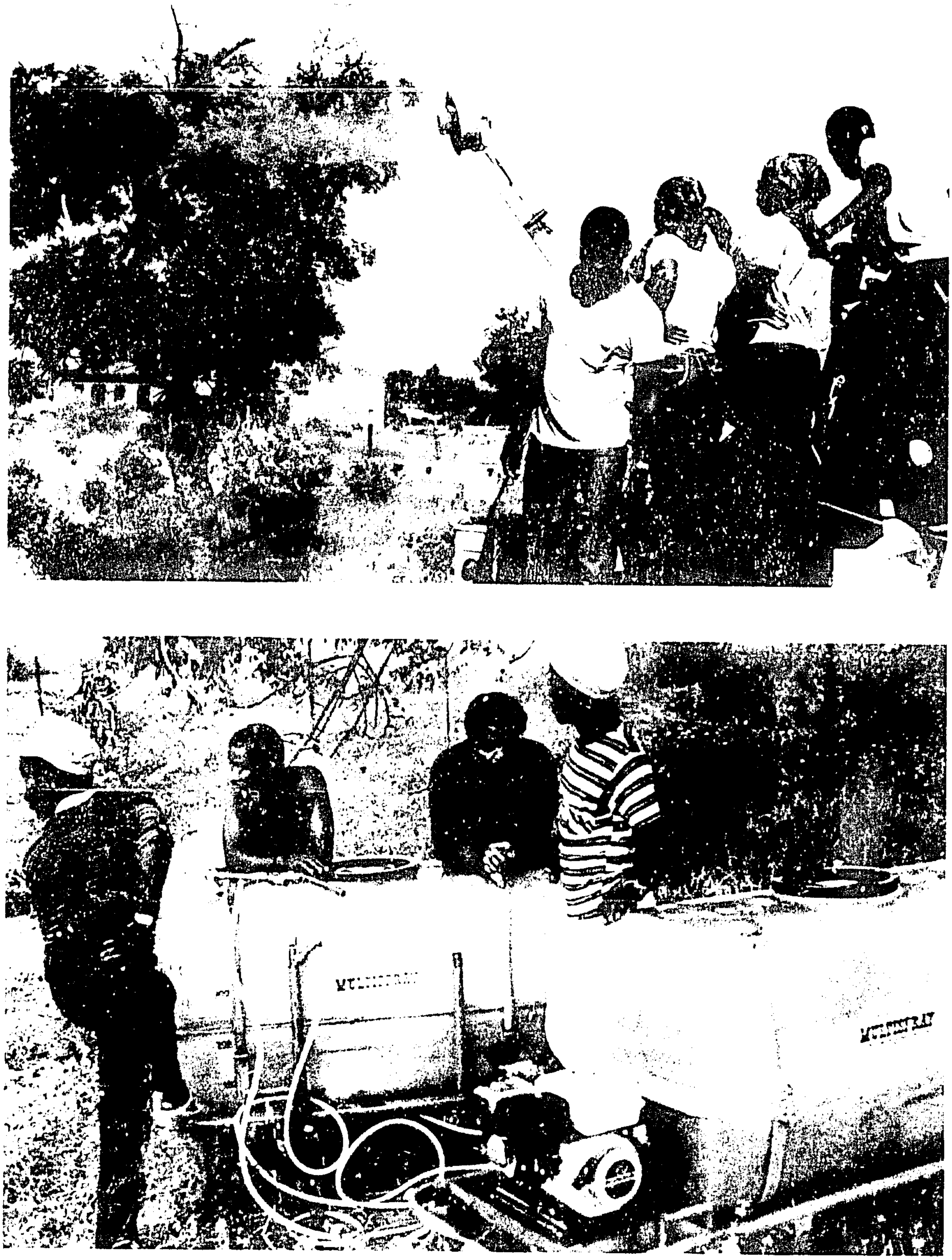
Type of request or activity	Total
Information on International Programs	20
Information or Literature on Research and Crop Protection Methods	80
Information on Graduate Schools in VPM	10
Materials/Photographs	10
Requests for DWRC Scientist TDY's	
- Project Development	5
- Workshops	1
- Symposia/Conferences	4
Requests for	
- Funds	11
- Research	7
- Training	35
- Hiring	6
No. International Visitors	26
No. Reprints Distributed	2,007
TOTAL	2,222

Originating countries:
Argentina, Australia, Bangladesh, Barbados, Botswana, Brazil, Canada, Chad, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, France, Galapagos, Grenada, Guatemala, Haiti, Honduras, India, Indonesia, Iran, Iraq, Italy, Jamaica, Japan, Kenya, Malaysia, Republic of the Maldives, Mexico, Mozambique, New Zealand, Nigeria, Pakistan, Panama, Peru, Philippines, Poland, Republic of China, Senegal, Somalia, Sudan, Taiwan, Tanzania, Trinidad, Uganda, United Arab Emirates, United Kingdom, United States of America, Uruguay, Venezuela, Zaire, Zimbabwe.

Village weavers are the main bird pest to cereals in Guinea-Bissau.

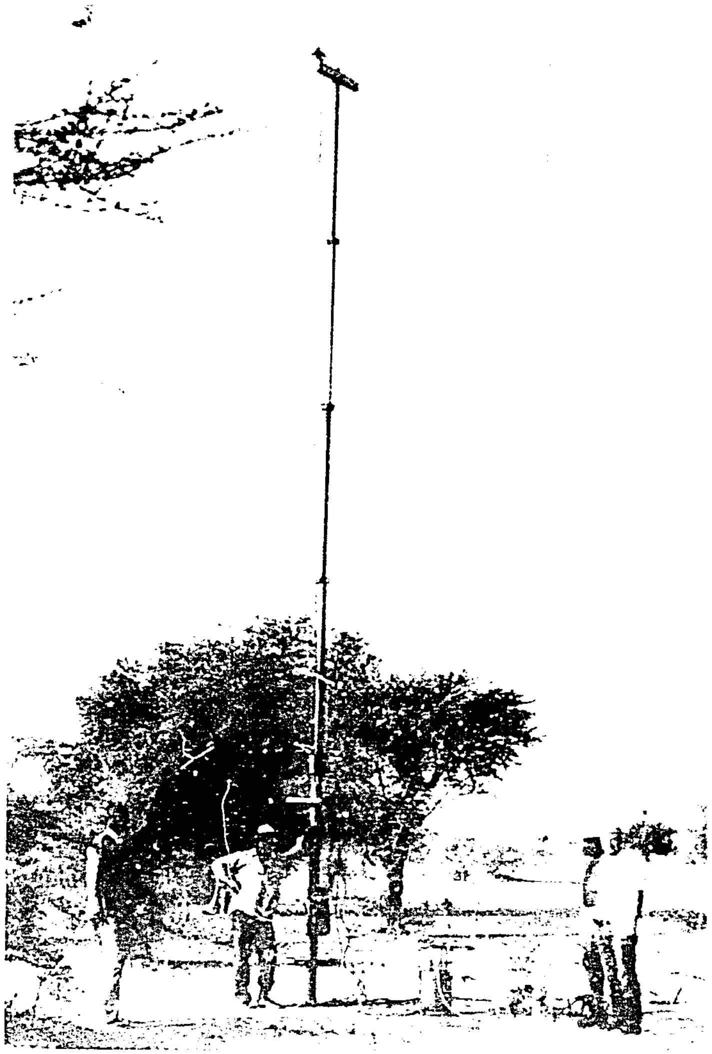
National Crop Protection Center in Guinea-Bissau.

Grain storage structure in Guinea-Bissau.



Micronair AU 7000 and multispray groundsprayers were evaluated in Botswana to control small roosts of red-billed quelea.

A training course on quelea survey and control was given at the Southern Regional Training Center in Botswana.



GTZ groundsprayers were used to mass-mark quelea and golden sparrows with fluorescent paint particles, and 0.9-g radio transmitters were attached to individuals of the same species to determine movements among island roosts and rice schemes in Niger.

TECHNICAL ASSISTANCE AND TRAINING

Richard L. Bruggers traveled (1) to Botswana to assist the Ministry of Agriculture (MOA) and FAO personnel in quelea bird survey, control, and crop protection efforts; (2) to Niger (with Jean B. Bourassa, Bioelectronics Project) to assist MOA and German Technical Assistance (GTZ) personnel in monitoring the movements of golden sparrows in and around rice schemes; and (3) to Guinea-Bissau to assist Ministry of Rural Development and Fisheries and USAID in defining and better understanding the bird pest problems relative to cereal crop production.

Several IPRS scientists responded to emergency requests for assistance to Sahelian countries of Africa in response to a rodent population irruption. G. Keith LaVoie and Donald J. Elias (FAO Vertebrate Pest Officer) surveyed rodent problems in Senegal, Chad, Mali, and Burkina Faso, Lynwood A. Fiedler visited Sudan twice, James O. Keith (Mammal Control Research Section) also visited Sudan, and G. Clay Mitchell also visited Chad to evaluate rodent control methods and provide technical assistance and training to MOA personnel during their rodent control operations. The rodent outbreak in these Sahelian countries followed a drought between 1980 and 1984 and good rains in 1985; similar outbreaks occurred in the 1960's and 1970's. In Sudan, several crops, crop stages, and rodent species were involved. Generally, however, the problem was twofold: (1) arid-tolerant, seed-eating rodents (Tatera spp., Jaculus spp., and probably Gerbillus spp.) were threatening seeded fields, and (2) arid-intolerant species (Praomys spp. [Mastomys spp.] and Arvicanthis spp.) were threatening maturing crops and harvested grains. Crop damage was as high as 65-100% in some areas, and plans were made for intensive rodent control in most Sahelian countries during 1987. In western Sudan, the Plant Protection Department applied over 1,500 t of 1% zinc phosphide bait in June and July. DWRC scientists helped evaluate the effectiveness of the zinc phosphide campaign and developed a warfarin program for rodent control in villages. About 660 t of warfarin bait will be distributed in about 8,000 villages in western Sudan. Other sites were treated with brodifacoum to remove rodents that had probably become bait-shy to zinc phosphide. Plans also were made for rodent control in villages and an additional treatment of fields just before harvest in late October.

Lynwood Fiedler made two consultancies to the Caribbean to organize a pilot program and conduct a training course on rodent biology and control for Ministry personnel of the islands of Antigua/Barbuda, Barbados, Dominica, Grenada, St. Christopher/Nevis, St. Lucia, and St. Vincent/ Grenadines.

Keith LaVoie was in Montserrat, West Indies, March 2-25, for the third DWRC consultancy on rodent control. The objectives of the trip were to evaluate ongoing rodent control activities in urban and agricultural sectors initiated in July 1986 and make recommendations or adjustments to these rodent control activities. Keith LaVoie and Richard A. Dolbeer (Bird Control Research Section) also made trips to the Republic of the Maldives to continue an assessment of vertebrate pest damage and the implementation of control techniques for bats, rats, and crows.

David L. Otis (Bird Control Research Section) visited the Bangladesh Vertebrate Pest Project from April 11-May 1 to provide guidance and recommendations on sampling techniques and experimental design used to e aluate vertebrate control strategies. He also provided the staff with many examples of quantitative techniques that can be used to evaluate the adequacy of sampling and experimental protocols and some insight into the theory behind these techniques.

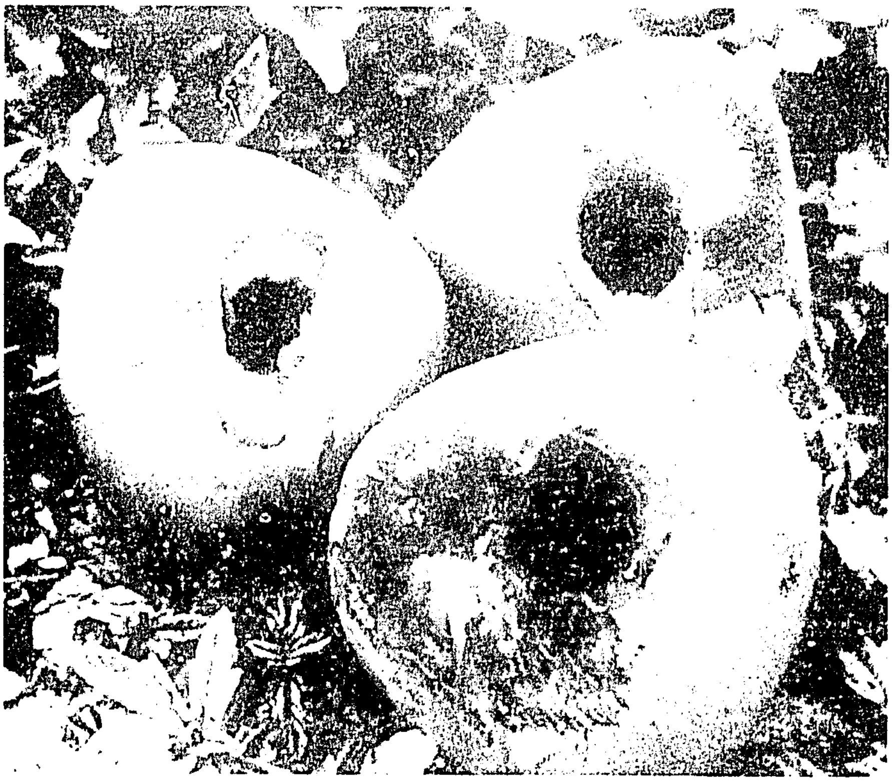
IPRS continued to participate in the Vertebrate Pest Management course offered at Colorado State University (CSU), Fort Collins, Colorado. Three foreign students (Herbert Okurut-Akol, Uganda; Ethel Rodriguez, Uruguay; and Maria E. Zaccagnini, Argentina) began graduate programs in Vertebrate Pest Management at CSU. DWRC/IPRS personnel have been involved in planning and organizing the thesis research of these students. In addition, Dr. Sohail Soliman, postdoctorate candidate from Egypt at CSU, conducted research at DWRC on grooming behavior as a means of delivering a toxicant to rats.

IPRS, in cooperation with CSU, hosted a 2-week "Short Course in Vertebrate Pest Problems and Solutions in Developing Countries." This course was the first ever conducted by DWRC and CSU on vertebrate pests for international vertebrate pest researchers and managers. Twenty-one individuals from 12 countries participated. Several individuals wish to return for postgraduate degrees at CSU, and others have indicated an interest in beginning or developing greater cooperation between DWRC and host countries to resolve pest problems.

Felipe Cruz, Terrestrial Ecologist, Charles Darwin Research Station, Galapagos Islands, visited DWRC for a training program in animal pest control. In recent years, DWRC scientists have traveled to the Galapagos Islands to assist personnel at the Charles Darwin Research Station in the control of feral animals that are affecting the wildlife on the islands. After spending a month at DWRC, Mr. Cruz traveled to the DWRC Field Station in Hawaii, where vertebrate pest problems are similar to those in the Galapagos Islands, to work with mongoose and feral pigs.

Progress was made on two joint projects funded by FAO. The first draft of an annotated rodent bibliography for Latin America 1960-1985 was sent to FAO in Rome. The bibliography consists of about 1,500 citations in English, Spanish, Portuguese, Dutch, French, German, and Italian. FAO also reviewed the first draft of a rodent control manual "Rodent Pest Management in Eastern Africa."

Fruit bats (Pteropus giganteus) are serious pests of several fruit crops in the Republic of the Maldives. The use of mist-nets to selectively reduce bat densities provided effective, economical, and safe damage control methods.



Black rats (Rattus rattus) limit coconut production in the Republic of the Maldives, destroying about 40% of the crop each year.

Rodenticides are evaluated in Chad to select those that safely and economically reduce the losses to farmers.

Sahelian rodents are captured to determine identification, species composition, and population densities, information that is essential to developing safe and effective damage control methods.

Rodenticides are placed in bait stations near crops to evaluate their efficacy to reduce Nile rat (Arvicanthis niloticus) populations in Chad.

International Programs Research Section[1]

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Lynwood A. Fiedler	Wildlife Biologist
Michael M. Jaeger	Zoologist (Bangladesh)
G. Keith LaVoie	Wildlife Biologist
G. Clay Mitchell	Wildlife Biologist
Donna J. Scott	Program Assistant
Annaliese E. Valvano	Editorial Assistant
Sandra L. Vana-Miller	Biological Technician

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Richard A. Dolbeer	Wildlife Biologist
Michael W. Fall	Chief, Predator Control Research Section
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James O. Keith	Wildlife Biologist
David L. Otis	Chief, Bird Control Research Section
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Iftikhar Hussain
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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.

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Date	Name	Representing
Mar 16-20	Mr. Herbert Okurut-Akol	Uganda (Graduate student at Colorado State University, Fort Collins, Colorado)
Mar 20	Ms. Ethel Rodriguez	Uruguay
	Ms. Maria E. Zaccagnini	Argentina
	Ms. Elisabeth Aguilera-Garramuno	Colombia
		(Graduate students at Colorado State University, Fort Collins, Colorado)
Jun 1-Dec 31	Dr. Sohail Soliman	Ain Shams University, Faculty of Science, Department of Zoology, Abbasia, Cairo, A.R. Egypt
Jun 3	Dr. Hugh Spencer	University of Wollongong, Australia
Jun 25-27	Dr. Umar Khan Baloch	Plant Protection, Pakistan Agriculture Research Council
Jul 24	Dr. El Sadig Bashir	Food and Agriculture Organization, Botswana
Jul 30-31	Ms. Elisabeth Aguilera-Garramuno	Colombia
	Mr. Ejaz Ahmad	Pakistan
	Mr. Habib Ahmad	Pakistan
	Mr. Md. Sayed Ahmed	Bangladesh
	Dr. Daniel Evans	Ecuador
	Mr. Iftikhar Hussain	Pakistan
	Mr. Kau-Hung Lu	Republic of China
	Mr. Ray Makwehe	Zimbabwe
	Mr. Kepha Moses Mogoi	Kenya
	Mr. Daniel Mosarwe	Botswana
	Mr. Pharoah Mosupi	Botswana
	Mr. Shahid Munir	Pakistan
	Mr. Herbert Okurut-Akol	Uganda
	Mr. Clement Otim	Uganda
	Mr. Christopher Pakenham	Zimbabwe
	Ms. Ethel Rodriguez	Uruguay
	Dr. Sohail Soliman	Egypt
	Mr. Danilo Valencia-Gutierrez	Colombia
	Mr. Po-Yu Wang	Republic of China

International Visitors (cont'd)

Date	Name	Representing
Jul 30-31 (cont'd)	Ms. Maria E. Zaccagnini Mr. Daniel Kinyata Zinabeine	Argentina Uganda (Participants in Short Course in Vertebrate Pest Problems and Solutions in Developing Countries)
Aug 27-28	Dr. David P. Cowan	Ministry of Agriculture, Fisheries and Food, Worplesdon Laboratory, United Kingdom
Aug 31-Nov 2	Mr. Felipe Cruz	Charles Darwin Research Station, Galapagos, Ecuador

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