XD-ABE-513-A
ISN 67615

EVALUATION OF VERTEBRATE PEST MANAGEMENT COMPONENT AGRICULTURAL RESEARCH PROJECT I - II BANGLADESH

Submitted by:

Associates in Rural Development, Inc.
110 Main Street, Fourth Floor
P.O. Box 1397
Burlington, VT 05402 USA

Team Leader, Paul Marko, M.Sc.
Vertebrate Biologist, William Jackson, Sc.D.
Entomologist, Monowar Ahmad, Ph.D.

Under AID Contract Number PDC-1406-I-08-7012-00

Date: 5 October 1989

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS i

PREFACE iii

I. EXECUTIVE SUMMARY 1

II. PROJECT PERFORMANCE 11

A. Project Background 11
B. Understanding of Biology and Economics of Vertebrate Pests in Bangladesh 18
C. Vertebrate Pest Component Work Plan 21
D. Denver Wildlife Research Center Site and Program Review 24
E. Environmental Impact 25
F. Rodenticide Quality 27
G. Vertebrate Pest Section Interface with Farming Systems Research under ARP-I, -II 28
H. Human Resources 33
I. Institutional Sustainability 35
J. Discussion of Logical Framework Assumptions and Outputs 38
K. Lessons Learned 39

III. RECOMMENDATIONS 43

REFERENCES 47

APPENDICES:

Appendix 1.0--DWRC Support Activities
Appendix 2.0--VPS Research, Training, and Extension Activities
Appendix 3.0--Project Design Summary Logical Framework
Appendix 4.0--Terms of Reference
Appendix 5.0--VPM Statement of Work
Appendix 6.0--Research Proposal and Grant Request
Appendix 7.0--VPM Workplan Outline 1986-1991
Appendix 8.0--The Impact of Jackal Depradation on Preharvest Rat Damage in Bangladesh, Technical Report No. 35, June 1989
Appendix 9.0--Project Scientists
Appendix 10.0-Zinc Phosphide Technical Assay
Appendix 11.0-BARC Workshop on the Status of Vertebrate Pest Research in Bangladesh
Appendix 12.0-List of Persons Interviewed

LIST OF ABBREVIATIONS AND ACRONYMS

AID	United States Agency for International Development
ARP-I, -II	Agricultural Research Project Phase I, II
ARP-II-S	ARP-II-Supplement, 1987-1991
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BDG	Bangladesh Government
BGSU	Bowling Green State University, Ohio
BRRI	Bangladesh Rice Research Institute
CSU	Colorado State University
DAE	Department of Agricultural Extension
DWRC	Denver Wildlife Research Center
FAO	Food and Agriculture Organization of United Nations
FSR	Farming Systems Research
GOB	Government of Bangladesh
GTZ	Gesellschaft fur Technische Zusammenarbeit
IPM	Integrated Pest Management
IPRS	International Programs Research Section (DWRC)
ISNAR	International Service for National Agricultural Research
MOA	Ministry of Agriculture
ARP	National Agricultural Research Plan
NARS	National Agricultural Research System
NGO	Nongovernmental Organization
OFRD	On-farm Research Division
OICD	Office of International Cooperation and Development
PASA	Participating Agency Service Agreement
PPW	Plant Protection Wing
TA	Technical Assistance
TDY	Temporary Duty
Tk	Taka (Bangladesh Currency Unit)
T&V	Training and Visit System of Extension
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
VPC	Vertebrate Pest Component
VPM	Vertebrate Pest Management
VPS	Vertebrate Pest Section

PREFACE

This was the first major external evaluation of the Vertebrate Pest Management Research component under the USAID Agricultural Research Project-Phase II (ARP-II). The evaluation team was composed of a Farming Systems Research (FSR) and Extension Specialist/Team Leader, a Vertebrate Pest Management Biologist, and an Entomologist.

Team Leader, Paul N. Marko (M.Sc., Senior Agronomist, Associates in Rural Development, Inc.). Mr. Marko has 25 years of experience in agricultural development, and 18 years in on-farm adaptive research, including FSR. He has previously worked for CIMMYT as a production agronomist and for The World Bank as a project officer.

Vertebrate Pest Management Biologist, Dr. William B. Jackson (Sc.D.). Dr. Jackson, Distinguished Professor of Biological Sciences, Emeritus, has been a professor of biological sciences at Bowling Green State University, Bowling Green, Ohio, since 1957. Dr. Jackson has held positions as the Assistant Dean of the College of Liberal Arts, Assistant Dean of the Graduate School for Research and Advanced Studies, Director of the Environmental Studies Center, and Director of the Center for Environmental Research and Services. Dr. Jackson has done extensive project evaluations in Vertebrate Pest Management, both for private- and public-sector organizations.

Entomologist, Dr. Monawar Ahmad (Ph.D., Bangladesh Agricultural University, Mymensingh). Dr. Ahmad has been Professor of Entomology since 1973. He as served as Head of Department; Dean, Faculty of Agriculture; and Coordinator of the Committee for Advanced Studies and Research. Dr. Ahmad has served on the evaluation of ARP-II and the Rapid Rural Appraisal Study of the APR-II/Winrock International.

As per terms of the contract, the Team Leader (Paul N. Marko) and the Vertebrate Pest Management (VPM) Biologist (W. B. Jackson) visited and reviewed the home office program documentation at the Denver Wildlife Research Center (DWRC) in Denver, Colorado, prior to their departure for Bangladesh. In Bangladesh, the evaluation team reviewed the key project documents/reports, conducted interviews at the Bangladesh Agricultural Research Council (BARC); the Bangladesh Agricultural Research Institute (BARI); the Bangladesh Rice Research Institute (BRRI), Directorate of Agricultural Extension (DAE)/Plant Protection Wing; Checchi and Company Consulting, Inc. (current ARP-II technical assistance contractor); the Department of Food Security; FAO Country Representative; and with pesticide importers (Appendix 12.0). During visits to current and potential field rodent research sites (Manikgonj, Mirzapur,

Comilla), small rice farmers were interviewed. The jackal study site at Sriput also was explored.

The evaluation team wishes to particularly acknowledge the support of Dr. M. M. Rahman, Executive Vice-Chairman, BARC; Dr. R. Morton, OFA/USAID; Mr. Latifur Rahman, USAID; Mr. A. Hankins, Consultant to USAID; and Drs. R. Bruggers and M. Jaeger of the DWRC, in arranging in-country itineraries and meetings and in giving the evaluation team the benefit of their expert knowledge of the agricultural sector and, in particular, the constraints to research.

I. EXECUTIVE SUMMARY

In 1978, the U.S. Agency for International Development (USAID) began providing assistance to the Bangladesh Agricultural Research Council (BARC) in response to their strategic plan to address serious crop losses caused by vertebrate pests. A Vertebrate Pest Section (VPS) was created within the Bangladesh Agricultural Research Institute (BARI) to develop the long-term research capacity to meet the continuing challenge of vertebrate pest management. The research program has resulted in the development of reliable estimation methods which currently place pre-harvest rice and wheat losses from rats at U.S. $130 million annually (Taka 4,277 million).

The overall objectives of the Vertebrate Pest Component (VPC) within the USAID-financed Agricultural Research Project (ARP-I and ARP-II) have been to:

- identify vertebrate pest problems;
- evaluate control techniques;
- develop strategies to manage vertebrate pests;
- train staff; and
- develop institutional identity, leading to institutionalization of vertebrate pest management research and extension capacity in Bangladesh.

The originally approved work plan called for a research focus on wheat, primarily as a result of the larger national effort at the introduction and expansion of wheat production in response to import substitution pressures. While accepting the national prioritization of wheat as the crop of focus for the research program, the VPC work plan was developed in explicit recognition that real success in long-term pest management strategies (rat control in wheat) would not be forthcoming following various short-term campaigns (e.g., offering bounty on tails). Rather, a field-oriented research and extension program needed to be developed which could provide continuous feedback to the basic vertebrate biological research effort. In the case of the Lesser Bandicoot Rat (*Bandicota bengalensis*), which is the major pest in wheat and rice in Bangladesh, control techniques needed to be developed and tested to intervene at the most vulnerable point in the rodent's reproductive life cycle, which can shift over time due to environmental factors.

Within the VPC wheat research program, the work plan called for rodent biology studies and rodenticide testing as a basis for evaluating a management strategy which would be economically feasible and acceptable to small farmers. The wheat rat control

research program continued for six years (1978 to 1984) and through its first full-scale field test to determine the efficacy of zinc phosphide baiting techniques. The field test proved successful in controlling rat populations in wheat using BARI laboratory-prepared bait. However, subsequent use of zinc phosphide baits by small farmers failed because locally produced baits proved adulterated. Farmers lost confidence in the technology and the situation reverted back to traditional individual methods of control, which, by their nature, are not effective.

At this point, there was a hiatus in the resident Denver Wildlife Research Center (DWRC) research leadership with a one-year transition of team leaders. During this period, DWRC intermittently provided the future resident team leader to VPS on short-term assignment. The transition period was used by DWRC to assist the VPS staff in examining the shortcomings of the previous research focus and field campaigns. At this time, rice was identified as the priority crop in which to control vertebrate pests due to its importance in national agricultural production and small farm income.

Since 1986, the VPS, with the consistent leadership of the DWRC resident team leader and support of DWRC U.S.-based research facilities, has developed a control technique for rats in *T. Aman* rice (the major rice crop) which explicitly recognizes the problems incurred with previous control strategies. Demonstration of this new management technique for *T. Aman* rice will occur in September and October of 1989.

The institutionalization process of the vertebrate pest management capacity within BARI has taken great strides forward with the formal degree training of two masters degree and three Ph.D. scientists who now hold research positions in the Vertebrate Pest Management Section within the Division of Entomology. However, institutionalization within the originally envisioned context of creating a "division" for vertebrate pest management within BARI has not occurred, primarily as a result of administrative decisions made within the existing Division of Entomology. Sustainable vertebrate pest management research capability requires a field research orientation to provide important behavioral and biological feedback to on-station basic research programs. This field orientation is at odds with the more traditional entomological research approach which is dependent upon laboratory control. Consequently, until the issue of administrative autonomy for the VPS is resolved within BARI, sustainable institutionalization of vertebrate pest management research capacity will remain limited.

The VPS, in collaboration with DWRC, has substantially met its work plan and has managed project implementation well. Deviations have resulted from a need to study additional aspects

of the management program more carefully. The success is due to a dedicated staff and their vigorous work under rigorous conditions. However, having substantially met the terms of the original work plan is not a reason to curtail support to the institutional development of the VPS. Rather, the continued strengthening of the VPS to enable them to respond to the changing nature of the vertebrate pest spectrum over time is prerequisite to increasing overall output and farm-level incomes in Bangladesh.

Rodent Control

From early in the project, it was recognized that pre-harvest rat damage was the most serious vertebrate pest problem in Bangladesh. Research findings suggested that:

- damage was economically significant;
- the major pest species was the Lesser Bandicoot Rat (*Bandicota bengalensis*);
- losses were greatest in wheat and deepwater rice;
- zinc phosphide baits were a cost-effective, environmentally suitable, and practical means of control; and
- baiting was most effective if directed at the rat burrow systems before panicle development.

Transferring this technology to the farmers was the objective of VPS/BARI's participation in the 1983 and 1984 National Rat Control campaigns organized by the *Gesellschaft fur Technische Zusammenarbeit* (GTZ)/Department of Agricultural Extension (DAE), in cooperation with the Food and Agriculture Organization (FAO). The campaigns were successful in increasing farmer participation in pre-harvest rat control.

However, by 1986, it was evident that this technology was not taking hold, and farmers were losing confidence in the control methods. There were two general explanations for this:

- the zinc phosphide baits were ineffective; and/or
- the farmers were seeing no overall reduction in rat numbers.

In 1986, a long-term research plan designed to resolve the pre-harvest rat problem was developed by the VPS/BARI scientists and the DWRC team leader. First, a large-scale field study was undertaken to determine a strategy for when and where control

should be focused in order to be the most cost-effective. This assumed that long-term population reduction was impractical and annual control was necessary. Secondly, the control methodology was re-evaluated and an alternative method identified, which did not depend on the market-available bait in question and therefore avoided potential problems related to food preferences. In addition, the problems with the use and marketing of zinc phosphide were identified.

At the time of this evaluation, plans were underway to re-introduce the modified pre-harvest rat control technology to the Bangladeshi farmers. However, the approach this time was more systematic, and the results were vigorously monitored to identify where in the extension process problems were occurring:

- farmer acceptance;
- farmer training; and/or
- product quality and availability.

Rodenticide Quality

Assuring rodenticide quality is essential to successful control campaigns. Past efforts have faltered because of adulterated zinc phosphide. A current study by DWRC determined that 19 of 21 brands available to farmers were substandard and would not kill rats. While the VPS demonstrations scheduled for Fall 1989 will use VPS-prepared baits of documented toxicity, future campaigns must be guaranteed ready availability of effective rodenticides.

Vertebrate Pest Section Administration

VPS is currently a section under the Division of Entomology (BARI). Project as well as BARC and BARI documents have recommended that VPS be separated and given division status. It has been indicated that this may be accomplished under the next five-year plan (to be initiated in 1990). In taking this highly recommended administrative action, it is important for BARI to assure that sufficient operating resources also are transferred.

The new Division Head should be highly qualified. The individual should have an outstanding academic record and have directed significant research projects under both laboratory and field conditions. Careful selection of the Division Head is important, as the individual will have major responsibility for being an effective departmental spokesperson.

One problem with administrative assignments is that very promising research programs must be suspended because of the "red tape" demands on time. One consideration might be to institute a rotating chair, whereby an individual would be nominated to the post for a year (perhaps renewable for a second year), and then the responsibility would move to another member of the division.

Since most scientists receive little or no administrative training in their academic program, some consideration should be given to this type of training. The individuals currently in Ph.D. programs at Colorado State University will receive some training in research administration, but broader aspects (e.g., financial planning and personnel enhancement and management) are not included. The United States Department of Agriculture (USDA)/Office of International Cooperation and Development (OICD) and various land grant universities have developed more comprehensive training programs which are accessible through AID-supported participant training, and both present and future staff members should be considered for inclusion in these programs.

Graduate Education

Currently, all VPS professional staff have at least one graduate degree outside the country. This breadth of international experience is very beneficial and highly desirable. Such a standard should be maintained for future staff members.

The last of these scholars will not return for several years, but recruitment of additional individuals and planning for funding should be initiated to replace individuals leaving the program and to meet expansion needs.

Only one of the present staff has specific training with pest bird management. Since this area is one of future concern, plans should include training for additional expertise in this area.

Denver Wildlife Research Center (DWRC)

Since 1978, ongoing support by DWRC has included equipment procurement/shipping/installation, literature searches, statistical consultation, and manuscript preparation and review. DWRC staff have arranged various U.S. observation tours for Bangladeshi participants. Several Bangladeshi U.S. degree participants, including two currently in doctoral programs at Colorado State University, have been advised and assisted by DWRC staff.

Other Bangladeshi participants have taken part in DWRC-provided, in-country, short-term training programs. DWRC technical consultants have assisted with on-site staff training in preparation for handling and observing jackals, including radio telemetry, pesticide efficacy testing, and design of statistically appropriate sampling procedures. The DWRC International Pest Research Section frequently has assisted in research design, collection of field data, data interpretation, and administrative matters.

The DWRC Analytical Chemistry Section recently completed an assay of over 100 samples of 21 brands of zinc phosphide, finding that only 10 percent of them would make effective baits. Another set of samples is currently being tested.

If sufficient funding is available, it is likely that after 1990, DWRC personnel support will be in the form of short-term TDY assignments. This should be satisfactory--assuming that the personnel, support, and organizational matters already indicated move forward satisfactorily. This is consistent with DWRC's philosophy of VPS becoming a "sister institution" and sharing expertise and technology.

The Vertebrate Pest Section Linkage with Farming Systems Research

Integration of the VPS research results into ongoing FSR activities under ARP-II has been discontinuous and severely limited by organizational and professional constraints. However, the need for VPS to maintain links to the Bangladeshi farmer has been consistently met through the cooperation between VPS staff and the Department of Agricultural Extension. This reached a high point in 1984 and has been sustained, although recently at a lower level of activity, while developing basic biological information on rat control strategies in *T. Aman* rice production.

There are a number of organizational and professional constraints to improved VPS/FSR integration. Of those reviewed during evaluation, the most outstanding were:

- lack of reliable economic data from crop loss estimates and costs of implementing rodent control recommendations at the farmer level.

- delay in building a complete FSR research team under ARP-II, which did not allow sufficient time for its members to focus on VPC research recommendations and incorporate them into current off-station testing; and

- strict adherence to an agreed-upon research plan for VPS to develop the basic biological information for a rat control strategy in *T. Aman* rice which has limited the opportunity for VPS contact with FSR personnel at the field and national levels.

Sustainability of the Vertebrate Pest Section

Sustainability of the VPS within the BARI research organization can only result from the overall creative output of each member of the VPS research team. This can be facilitated by a well-designed and administrated professional relationship with other existing research sections in BARI. Presently, the VPS is in an ambiguous organizational and professional position in that it does not fit the traditional concepts of research methodology and approach of Integrated Pest Management (IPM) and entomology within BARI. This situation results in competition for available resources within the same division, which, when related to the lower divisional priorities of vertebrate pest management research, does not argue well for institutional sustainability of this capacity. It will require a restructuring of the VPS as a separate division in BARI to achieve the full potential of its staff.

Administrative restructuring of the VPS to establish it as a division will require careful examination of the leadership available in-country and being trained outside the country. As discussed above, supplementary training to improve research management and administration should be considered a priority use of participant training funds.

The VPS will only be sustainable in the political and economic sense if it can demonstrate its capacity to provide technical solutions to the control of economic vertebrate pests of the Bangladeshi farmer. This capacity can be realized if administrative and organizational funding permit ease of access to the farmer. Transportation, per diem, and research material have to be made available on time. In the particular case of the upcoming field verification trials, dependable access to funding will be critical, as the results of these trials pull together the basic parts of a biological study that was expensive and difficult to carry out. The successful implementation of VPS' large-scale farmer verification trial in September will assure a comprehensive strategy for a national effort to control rats in *T. Aman* rice. This has both political and economic implications for the sustainability of the VPS.

In order to further strengthen the VPS and improve its utility in generating viable technical options to the Bangladeshi farmer, the recently established National Committee for Vertebrate Pest Research has to fulfill its function by

facilitating the integration of VPS research with Farm Systems Research (FSR) and national extension programs, and should assume the role of developing policy on national vertebrate pest management issues.

The level of technology recommended by the project features a simple, pre-mixed, environmentally safe, locally manufactured rodenticide that can be applied easily by the individual farmer. Its low cost (0.05 Taka/bait), makes it available to all farmers. The results from previous controlled farmer testing in wheat indicate that when farmers can buy a quality formulated and unadulterated zinc phosphide rat bait, they will continue to purchase and employ it as a rodenticide. The sustainability of this technology can only be maintained if those regulatory agencies that provide oversight for bait manufacturers fulfill their functions.

Conclusion and Selected Recommendations

The VPS is achieving a major objective of being able to transfer a control strategy for bandicoot rats in rice to the farmer community. Continued activity relative to this technology transfer as well as development of control strategies for other cropping schemes and other pests (e.g., birds, jackals, wild pigs) is highly desirable.

VPS has performed a highly creditable research task and is now entering an extensive field-testing phase to adapt its research findings to farmer needs. The management strategy for the bandicoot rat in rice, if adopted by farmers, will reduce significantly pre- and post-harvest losses. The evaluation of the socioeconomic aspect of the technique is the critical last phase of this long and highly important research and development effort.

Carrying through the program fully from the start with basic research on the biology of the rat species to the adaptation of techniques, to the crop environment, and finally, to farmer-initiated implementation, is important. It becomes a model which can be replicated by VPS staff and extended to other important cropping systems and pests. Only through mounting the effort to replicate the research methodology developed thus far can the sustainability of staff capacity and the process of institutionalization be assessed.

Selected Recommendations:

It is recommended that, as a minimum, planned USAID obligations to VPC and the DWRC be continued through ARP-II (1993). Maintaining adequate and continuous funding will allow for important short-term technical and other DWRC facilities' support to VPS after 1990.

The establishment of VPS as a separate division in BARI should be accomplished within the year. Designating the new Division Head is an extremely important administrative decision. The most qualified individual in academic preparation and laboratory and field research experience should be selected.

The Plant Protection Department (PPD) of DAE should alert its staff to the serious problem of zinc phosphide adulteration. PPD should initiate an inspection, testing, and enforcement program to remove these substandard chemicals from the market.

Government of Bangladesh (GOB) consideration should be given to local entrepreneurial groups who could manufacture and guarantee quality baits in their region. Women's groups, especially those aided by Nongovernmental Organization (NGO) financing, might be considered.

The evaluation team recommends that VPS immediately solicit the services of a Bangladeshi economist with strong field experience to develop a sound quantitative basis for interpreting the results of the VPS field test in September. A regional FSR agronomist now assigned to multilocation testing should also be seconded for the duration of the Fall 1989 VPS field testing and take an active role in the VPS on-farm testing activities. These assignments could serve an important function in establishing linkages with existing FSR programs and provide essential in-service training required for sustainable implementation by FSR personnel of future rat control technology.

The Technical Committee formed by the BARC should be convened and strengthened to improve VPS' coordination and input into extension, as well as FSR and national vertebrate pest management policy. The socioeconomic information resulting from the Fall 1989 field test should be utilized by the National Committee on Vertebrate Pest Research to ensure that this information is transferred to the Department of Agricultural Extension and other BARI/FSR activities. The committee should also study the forthcoming information to determine if there are policy issues that remain to be resolved in relation to the pest management technology transfer process. This committee should respond immediately to its terms of reference, including meeting at least once each quarter (Appendix 4.0).

In order to support the immediate needs of the Fall 1989 large-scale test of rat control in *T. Aman* rice, timely allocation of financial and other field research resources should be made to the VPS. It is suggested that due to the critical role of this September trial, alternate means of funding should be considered if PL 480 funds cannot be easily accessed. The use of PL 480 funds should be phased in systematically, so that current research plans are not limited by loss of funding.

II. PROJECT PERFORMANCE

A. Project Background

The Agricultural Research Project-Phase I (ARP-I 388-0003) was initiated in FY 1976 to assist the Government of Bangladesh in adequately equipping and fully staffing the Bangladesh Agricultural Research Institute (BARI)--an institution under the jurisdiction of the Bangladesh Agricultural Research Council (BARC) of the Ministry of Agriculture (MOA), created to produce biological and economic research results in non-rice food crops. The ARP-I supported the Bangladesh research program with technical assistance, training, commodities, and other activities that supported in-country research. The Vertebrate Pest Component (VPC) was initiated under ARP-I through a project amendment (388-0003-1) signed in April 1978 to develop pest management techniques suitable for small farmers.

The Agricultural Research Project-Phase II (ARP-II 388-0051), which was initiated in December 1980, continued the Vertebrate Pest Component. The purpose of ARP-II was to continue efforts begun under ARP-I to upgrade Bangladesh Government (BDG) research capabilities in the core research areas of agricultural economics, crop and livestock development, soil and water, and pest management.

The VPC has been implemented within BARI, Joydevpur. As originally envisioned, the VPC was to be implemented through a newly established "division" within BARI to institutionalize an ongoing research capability. However, instead of being institutionalized as a division, the VPC has been functioning as a "section"--the Vertebrate Research Section (VPS)--under the administrative management of the Chief Scientific Officer of the Division of Entomology at BARI. Currently, the VPS is staffed with three Senior Scientific Officers and two Scientific Officers (Appendix 9.0).

Since 1978, technical assistance and other research program support to the VPC has been provided under a Participating Agency Service Agreement (PASA) with the Denver Wildlife Research Center (DWRC) located in Denver, Colorado. DWRC has provided one long-term resident scientist to act as project leader to VPS research program activities and to coordinate DWRC input and support. Since 1978, there have been three resident advisors in place continuously, with the exception of a one-year period of absence during 1985.

Relevance to Government of Bangladesh Agricultural Research Needs

Prior to the establishment of the Vertebrate Pest Component of ARP-I and -II, the Government of Bangladesh (GOB) faced a dilemma in the area of Vertebrate Pest Management. The GOB recognized that vertebrate pests caused serious crop losses in the country but could not judge with suitable reliability the extent of such losses. At the root of this was an almost complete dearth of research capability in the specialized field of VPM. Without this capacity, the GOB had no means to focus on the assessment and management of vertebrate pest problems in major staple and high-value cash crops. Consequently, control recommendations appeared unsuitable for the specific needs, pests, crops, and field conditions. For these reasons, the BARC 1988 Strategic Plan for National Agricultural Research to the year 2000 now contains the program element: "Establish fundamental principles and practices for the control of Vertebrate Pests".

With the establishment of the VPS at the Bangladesh Agricultural Research Institute, the GOB has acquired the capacity to provide reasonable estimates of vertebrate pest damage and develop economically feasible and acceptable pest management technologies over the long-term. The application of these new technologies provides small farmers with the potential for greatly reduced losses, increased crop yields, and income. In addition to the research contributions of the VPC, a wide range of specialized degree and non-degree training of Bangladeshi scientists in field-oriented VPM techniques is aimed at institutionalizing this research capacity within BARI.

Overview of Vertebrate Pest Component Activities and Research During ARP-I and -II

The approved VPC work plan called for conducting initial pest definition studies of jackals and rats, evaluating rodent damage in wheat, and assessing the impact of rodents in stored food commodities at the farm and village level. Second priority was given to assessing the problem of pest birds in sprouting wheat and jackal damage of sugarcane, maize, and poultry.

The initial pest definition studies identified rat damage in wheat as the major problem. Consequently, subsequent basic vertebrate biological research conducted by VPS under DWRC technical leadership and support focused on developing a rat management technology for wheat. This basic research was planned to complement the efforts of two other donors in vertebrate pest management. GTZ support to the Bangladesh Research Council (BARC) was focused on developing extension capabilities in pest management which could utilize particular types of bait. There was also an FAO project concentrating on the socioeconomic

aspects of post-harvest loss reduction. However, these two programs were terminated in 1984 and 1985, leaving only the USAID/DWRC-supported research component in vertebrate pest management.

In 1981, DWRC and VPS scientists began implementing applied field research to test the economic feasibility and farmer acceptability of a particular rodent control (baiting) method in wheat. The baiting control program involved working with the private sector to make and distribute zinc phosphide bait and relied on the GTZ/BARI Agricultural Extension Department (DAE) project to implement and assess the impact of the control effort.

During 1985, the work plan was revised with a new emphasis on rat control in *T. Aman* rice. The impetus for this change in focus from wheat to rice was the result of the survey work completed in 1984 and the explicit recognition of rice as a major crop in Bangladesh. The revised work plan emphasized the research priorities of pre-harvest rat damage to rice, the importance of post-harvest losses to rodents in houses, and the need for an in-depth analysis of jackals as pests in sugarcane and of poultry. The plan called for systematic and objective analyses of the interactions of these three possible pest situations for two years, to be followed with a field evaluation of possible control methods for one to two years (or part way into the present phase which ends in 1991).

Rodenticides: At the beginning of the project, very little information was available on the effect of the common rodenticides on the Bangladesh rodent fauna. This meant that basic toxicological studies had to be done on the common rodent pest species, namely Lesser Bandicoot Rat (*Bandicota bengalensis*), Greater Bandicoot Rat (*B. indica*). Roof Rat (*Rattus rattus*), and Short-tailed Mole Rat (*Nesokia indica*). The facilities at the project laboratory proved to be satisfactory for this toxicity testing. Toxicological studies were completed on three acute toxic rodenticides and several other materials have been partially evaluated. The LD50 values of zinc phosphide, benzene sulfonic acid hydrazide (DRC-4575), and bromethalin were determined for both sexes of *Bandicota bengalensis*. It was also found that brodifacoum was the most toxic of the three anticoagulants tested; this poison killed this species in four to eight days when animals fed on it only one day. Another anticoagulant of value was coumatetralyl (Racumin), which killed all rats when they fed on it for only two days. The material is presently registered and available in Bangladesh. Diphacinone, the third anticoagulant tested, was found to be the least toxic of the three and was not tested further.

Rodent pests to sugarcane: Three species of rats are found in sugarcane in Bangladesh: roof rats, short-tailed mole rats, and lesser bandicoot rats. Of these species, the roof rat is the most important. This rat invades sugarcane fields where the fields closely adjoin farmers' or village houses. Surveys of rat damage to sugarcane in the Sripur area disclosed that rats had damaged an average of 7.5 percent of the canes by harvest time; this equaled an average 14 percent weight loss between rat-damaged and the undamaged canes. The Mole Rat was found to invade sugarcane fields early in the cane growth cycle and inflict damage to the plants about three to four months after planting. Damage from this species then decreases until harvest, even though the rats remain on the field edges. No efforts at field control of rats in sugarcane have been attempted.

Bird repellents: Bird damage to food crops can quite often be reduced by the use of chemical repellents which inhibit birds from feeding on the crop, but are not generally lethal to them. Since there was no information on the effective dose and optimum concentration of these materials for the common pest bird species in Bangladesh, these materials had to be evaluated under laboratory conditions before they could be taken into the field. Three chemical repellents (copper oxychloride, methiocarb, and trimethacarb) and one toxic fright-inducing chemical (4-aminopyridine) were evaluated for their repellency and toxicities on four species of common pest birds: the rose-ringed parakeet (*Psitticula krameri*), the common pigeon (*Columba livia*), the house sparrow (*Passer domesticus*), and the black-backed munia (*Lonchura striata*). Although methiocarb was the most effective, copper oxychloride did repel birds and, because of its local availability and low cost, was considered more appropriate. The effect of 4-aminopyridine on parakeets, house sparrows, and munias justified further lab and field trials. It produced distress calls in parakeets within 10 to 20 minutes; normally in the field, these calls given by one bird would frighten the remaining members of a flock away from the area.

Bird damage to maize: Two species of birds, rose-ringed parakeets and jungle crows (*Corvus macrorynchos*), are the main pests of maize in Bangladesh. Most of the damage occurs from the "milk" stage through the "dough" stages. Jungle crows also damage maize during the sprouting stage. Early attempts at Dinajpur to control parakeet damage to maize used the distress-producing chemical, 4-aminopyridine. First, five maize cobs were exposed on each side of the field border by pulling back the leaf sheaths. The next day, these were removed. The chemical was dissolved in ethanol at two percent and four percent concentrations and hand-sprayed onto fresh maize cobs from which the leaf sheaths had been pulled back, again exposing five cobs on each side of the field borders.

Spraying at milk stage just once before harvest gave a 66 to 93 percent reduction in damage to maize ears at harvest compared to nearby untreated plots. The amount of chemical used per plot was inexpensive despite the cost of the material. However, the material is toxic to humans and all forms of wildlife and considered too hazardous for general farmer use in Bangladesh; research on it was discontinued.

Jackal toxicants and immobilization agents: The jackal (*Canis aureus*), has been tested with three toxicants for susceptibility: diphacinone, coumatetrlyl, and carbofuran. Either of these anticoagulants will kill jackals in the normal concentrations used in rodent baits in three days feeding. Carbofuran has been effective at 0.5 percent in baits, killing animals in less than one hour. All three materials appear promising as control chemicals and should receive further laboratory and field evaluations if jackal control is warranted. Ketamine hydrochloride was found to be an effective immobilization agent for jackals. After injection of 10 to 20 mg/kg, the animals could be handled within two to five minutes. Many animals have been successfully transported from trapping sites in the field back to holding facilities within one to two hours after immobilization.

Jackal damage surveys: An intensive interview survey of farmers about jackal problems was carried out in 11 districts of Bangladesh. The districts were pre-selected to represent the differing physiographic and ecologic areas of the country; but within each district, upazillas and villages were selected at random. A total of 979 (88.1 percent) of the 1,110 farmers interviewed reported problems with jackals: 286 (25.7 percent) reported damage to field crops, and 693 (62.4 percent) had lost domestic animals due to jackal depredation. Jackals most frequently damaged sugarcane, melons, pineapple, jackfruit, maize, groundnut, and cucumber. Jackals were reported to kill and eat chickens, goats, ducks, sheep, cattle, pigeons, and freshwater prawns.

The annual reported losses per farmer averaged Taka (Tk) 228 for crops and Tk 186 for domestic animals. The aggregate loss per farmer was Tk 414 (equals U.S. $16.12 per farmer). Extrapolating this to the 12 million farmers in Bangladesh resulted in an annual estimated toll of $193 million.

Jackals reportedly occurred throughout the countryside; they were reported by one or more farmers in each of the 220 villages that were visited. Farmers were found to do very little jackal control due to a lack of knowledge and resources. Farmers resorted to the use of night guards to protect some crops, such as sugarcane and watermelons, from damage.

Porcupine damage: Porcupines in Bangladesh damage root crops and pineapple. Only limited work has been done by the VPS on porcupines. One trial of coumatetralyl at the pineapple gardens of the Monaspara Seventh Day Adventist School in Netrakona was entirely successful in stopping damage in a period of two weeks of baiting. Coumatetralyl concentrate was dusted onto cubed ripe pineapple, and baits were placed out where fresh damage was found; baits were replenished as needed.

Summary of Previous Vertebrate Pest Component Internal Reviews

The only comments that were available regarding the Vertebrate Pest Component from the five internal reviews since 1981 are summarized, as follows:

The report of 1981 cites success with zinc phosphide bait cakes prepared by the Vertebrate Pest Section Laboratory and sold at cost to farmers. Those farmers who employed these baits (as directed) in wheat experienced a cost/benefit of 1:30, or one Tk invested resulted in a 30-Tk return. The benefits of copper oxychloride-treated fields for bird control in sprouting wheat gave a cost/benefit ratio of 1:32. The report also cites successful evaluation of brodifacoum rodenticide, but further evaluation was required.

The 1982 review (Anderson, et al. 1982) found the DWRC-supported vertebrate specialist to be well-versed in a broad range of vertebrate disciplines and with a long history of work experience in the region. The report considered this back-up from DWRC to be first-rate, and it was apparent that local staff were becoming adept at the design and implementation of experiments and survey programs.

It was noted that the DWRC Project Leader tried to integrate the rat-baiting technology (wheat production) into the cropping systems research field activities of ARP-II. However, attempts to do this were not met with enthusiasm by the larger ARP-II technical assistance team, and no progress was made in this area.

The 1984 internal evaluation made no mention of the VPS unit.

In the 1985 internal review, the extraordinary contributions of the DWRC Project Leader were heavily acknowledged. His previous regional experience in Asia with vertebrate pests and their control made his leadership and participation in the national rodent control campaign in wheat, and several additional surveys and trials, extremely effective (Riggs, et al. 1985).

The 1986 internal review simply noted that the vertebrate pest management work had benefitted from continuous long-term AID

funding of DWRC assistance. Even though there was disruption of resident DWRC team leadership during the previous year, DWRC had continued to provide short-term technical assistance for maintaining the ongoing research and training program and for program planning (Winrock 1986).

Summary of the Scope of Work Guiding the Evaluation of Vertebrate Pest Section under ARP-I and -II

The following project performance issues guided the evaluation team in its evaluation:

- the overall vertebrate research performance in meeting Bangladesh's needs in vertebrate research--the responsiveness of the VPS to national research and development objectives;

- the research outreach to the Bangladeshi user--the quality and quantity of communications with the Bangladeshi farmers and project management including BARC and DWRC;

- the socioeconomic dimension of the research and its impact on rural economic and cultural realities--the participation by women both in project implementation and as beneficiaries of the technology;

- the interface of the VPS with the overall ARP-II--particularly Farming Systems Research and overall management program under BARI;

- the VPS long-term institutional sustainability and stability; and

- the role, quality effectiveness, and appropriateness of technical support and backstopping of the Denver Wildlife Research Center (DWRC) to the VPS.

For a complete detailed Terms of Reference, see Appendix 5.0.

B. Understanding of Biology and Economics of Vertebrate Pests in Bangladesh

Vertebrate Pest Section Control Strategy

One objective of VPS has been to develop a strategy that allows the farmer to anticipate critical periods of rat damage and reduce crop loss using a rodenticide (or other control tool). The development of this farmer-management strategy requires systematic study of the biology and ecology of the particular rat species as well as the socioeconomic circumstances of the producer. This has not been a straightforward development in Bangladesh.

Development of a reliable rat damage-assessment tool is not a simple task; it depends on the species-specific habits of the dominant rat--in this case, the Bandicoot Rat. Further, prior understanding of its food preferences, breeding and movement patterns, and behavior is required.

The extent of the rat damage is not always recognized by the farmer until harvest, making his interest in control procedures that require action before the initiation of grain set difficult to obtain. Often, damage is not generalized across all locations, and consensus among farmers and field technicians on damage severity is not easily reached. The degree of farmer cooperation required to initiate effective control is difficult to achieve. For these and other generic development reasons, the evaluation of VPS achievements under ARP-I and -II is both challenging and difficult.

The annual control strategy focuses on *T. Aman* rice (both transplanted and broadcast), where rat damage exceeds that in wheat and *Boro* and *Aus* rice. Baiting of Bandicoot burrows should be undertaken prior to flowering, the greater availability of food, and the upward surge in reproduction. This sequence was formulated through arduous and extended investigations into the biology, food habits, and behavior of these rodents. The procedure was determined to be highly cost-effective and environmentally suitable. The techniques will be demonstrated on *T. Aman* rice in two large-scale trials in September and October 1989.

Other crops, as well as mixtures of crops, alternate seasonal patterns, and even different rodent species require adaptation of the management program to these ecological variables. Such parameters as different timing of baiting, more frequent baiting, or perhaps other bait application distribution procedures may need to be considered to accommodate the different cropping systems that currently exist.

Future research will need to examine this management program in other rice-cropping patterns and where other crops also are grown. Adaptations in timing of control practices may be necessary if benefits are to be maximized.

Biology of Vertebrate Pests in Bangladesh

Many aspects of a pest's biology, behavior, and ecology must be studied separately before a composite picture can be formed and a management plan developed. Since 1986, most efforts have been focused on the rodent problem in rice.

It was necessary to determine geographic distribution patterns of predominant species, feeding habits, behavior relating to traps and baits, and seasonal reproductive patterns. The impact of seasonal flooding and drought patterns had to be evaluated. Susceptibility and acceptability of candidate rodenticides and baits had to be determined. Laboratory tests, observations with semi-confined (penned) animals, and field trials were utilized in these systematic studies.

A census technique had to be developed to evaluate the impact of projected management programs. Often, this involves time-consuming trapping studies. However, since *Bandicota bengalensis* is the prime rice field infestant, an alternative and highly efficient procedure was devised. It was determined from pen studies that these rats always were found in individual burrows; therefore, simply counting active burrows provided an accurate population count. Furthermore, these rats consistently store food in their burrows; measurements from pen studies provided an accurate estimate of this hoarding and a basis for estimating economic loss.

Many tests last year confirmed the hypothesis that reduction of rats in *T. Aman* rice in September and October (prior to flowering) would have the most positive effect on yield and the most extended impact on the rat population. This year, large-scale demonstration field trials will be undertaken to evaluate several baiting strategies and to train extension and farm system workers in the procedures (Appendix 6.0)

In these trials (at Ishurdi and Comilla), 4,800-hectare study areas will be designated. Observation and sampling procedures were developed (with DWRC assistance) to provide statistically reliable measures of rodent population changes and crop losses. Consequently, the value of rodenticides and application methods can be evaluated and cost/benefit determinations made.

Similar attention is now being focused on predators. Cage food habit studies as well as field observations relative to

developing a census technique are underway and will need to be continued. Most important is learning enough about predator pre-relationships in this particular ecosystem to prevent the loss of predation benefits in rodent management through inadvertent (or unstudied) elimination of the ecosystem balance (Appendix 8.0).

Observations on crop losses to pest birds have been made, and some repellent tools have been tested or demonstrated. However, these crop losses were considered of lesser importance, and loss measurements and management tools are yet to be adequately investigated.

Economics of Vertebrate Pest Management in Bangladesh

The estimation of economic crop loss due to rat damage has been notable in the recent past for its lack of a systematic sampling method. Over the last three to four years of the VPS fieldwork, this methodology has improved with greater understanding of the feeding habits of the dominant rat species and the correlation between rat burrows counted and crop damage. The percentage loss assumed from recent VPS data indicates a loss range of from one to three percent per hectare. This is a more conservative estimate than previously assumed but results from a larger, more systematic data base.

Current estimated total production cost for *T. Aman* rice crop is Tk 7,383 per hectare (World Bank 1987), of which, only 20 percent is purchased inputs. VPS field studies have resulted in estimates of an average of 35 rat burrows per hectare. The cost of rodenticide (baits) is Tk .05 per burrow with application only once per year. The total rodenticide annual cost per hectare is Tk 1.75. Therefore, there is no financial reason for any small farmer in Bangladesh not to adopt the management technology. There is an additional consideration of labor; however, the allocation for baiting the burrows does not occur during the periods of peak labor requirements in the cropping cycle. Consequently, there should be no labor constraint in the adoption of this technology. Total cost per hectare in relation to total savings (one to three percent of total output) results in a strong case for adoption.

National losses due to burrowing rats in rice and wheat are estimated to reach as high as 500,000 metric tons (MT). This includes pre- and post-harvest loss. At current market value of wheat and rice delivered to Chittagong, this annual grain loss from burrowing rats represents U.S. $130 million.

Cropping intensity due to improved farming practices will increase. One can only speculate that unless damage from rats is controlled, the national losses will rise.

C. Vertebrate Pest Component Work Plan

For the purposes of this evaluation, the evaluation team was requested to limit its scope to the work plan developed by the DWRC Project Leader, VPS staff, and the head of the BARI Entomology Division for the period from 1986 to 1991 (Appendix 7.0). The work plan indicated that by 1988, baseline and test data would have been obtained on rat infestations in rice. In 1989/1990, implementation of a management program would be considered. A similar schedule was set for rodent infestations in grain stores. These activities are on schedule.

Jackal damage was to have been investigated, so that control tests could be initiated next year. The necessity of developing an adequate census technique requires that any population manipulation be delayed until a satisfactory means to measure the population is available. This will undoubtedly delay actual tests to the next year. A review of the need for control measures will be made after studies concerning the jackal's role in rat predation is analyzed.

Bird damage to crops was scheduled primarily for 1990/1991. Since those depredations were given a lower priority, it is likely that little activity in this area will occur immediately or in the next year.

In general, VPS has maintained the work plan. In the most crucial area of rats in rice, activities are right on schedule.

Research Approach and Accomplishments

The Vertebrate Pest Section, having changed its specific program priorities twice during its relatively long history, has moved carefully in the last three years to document rat damage to rice. Following detailed life history and behavior studies, it was possible to plan an annual management scheme involving a single pre-flowering baiting. Its efficacy was evaluated, and VPS is now ready for large-scale trials that evaluate rodenticide delivery systems and provide opportunity for extension and FSR personnel to work with VPS teams. While progress may have been slow, it followed an agreed-upon course and conducted well-designed studies which will provide data suitable for critical evaluation. This will be cited as a "model program" in years to come.

The jackal study is following a similar course. Because of the environmental quality issue involved (i.e., biodiversity), this will be watched carefully by many people. This provides a rare opportunity to examine closely a predator-prey relationship before a heavy control program has been launched. Quite

possibly, a "natural" means of rodent control may be enhanced. If so, undertaking farmer education and understanding will create some real challenges.

While the emphasis has been on rice, rat depredations on wheat are well-known, and some efforts on damage evaluation have continued. Concerns for related environmental issues will increase. Eventually, additional bird management tools need to be examined, but budget and staff limitations preclude any large-scale activities in the near future.

Rats, of course, infest other crops. Shortly, the technique for *T. Aman* rice will need to be adapted to other cropping schemes, which probably will not be as easy as it may seem. Efforts to assess post-harvest losses have started at the farmer level, and such depredations should be reduced consequent to area-wide field campaigns. Losses in godowns remain yet another concern.

Central to any evaluation are the people. VPS has a unique core of scientists, well-trained academically and experienced in the field, who should be kept together. Staff retention is related to recognition--financial and otherwise--and receiving administrative support to investigate important relationships. After the DWRC advisor leaves in another year, this latter component could be critical, as VPS, in the next decade, could greatly expand its scope of activities if provided with resources and support.

Vertebrate Pest Section Research Capability

Research quality is difficult to judge because diverse criteria may be used. However, by almost any judgment pattern, the VPS professional staff rates well above average. All five members have broadened their experience by obtaining at least one graduate degree abroad. One doctoral student is still completing his program (Appendix 9.0). Additionally, one BRRI member is completing a doctoral degree with DWRC assistance.

Scholarly output is another criterion. The staff have produced or been involved in more than 30 publications, many in international journals, and additional papers by DWRC scientists are based on Bangladesh-related data (Appendix 2.0--Sections 2.6, 2.7, and 2.8). While such publications are often highly technical, they serve to establish these scientists as knowledgeable professionals with world standing. They are thus better able to participate in the large scientific community as well as serve VPS and the interests of BARI and farmers of the country.

Participation in conferences and training programs is yet another path for judgment. A partial list of such involvements is presented in Appendix 2.0--Section 2.5. Of particular note is that active participation by making a preservation frequently occurs.

Participation in various local or in-country programs is another criterion for evaluation. The staff have cooperated with other groups of BARI, with other administrative units (BRRI, BARC, DAE) in providing training presentations and participating in radio interviews (Appendix 2.0--Section 2.3).

In the end, it is the dedication of the individual to his or her assignment. The professional staff is exceptional in this regard. Some studies require frequent all-night observations. In deepwater rice, immersion is a frequent occurrence. Digging up burrow systems and collecting field data all day long are consuming activities. The staff in general is to be commended for their efforts and professional dedication.

Research Facilities, Joydevpur

The laboratory at Joydevpur now has outdoor pen facilities for jackals as well as rats. These are well-maintained and used for various kinds of food habit and behavior studies. The indoor animal holding facilities are inadequate, and lack facilities for cleaning cages, storage of food and supplies, and isolation of newly-captured rodents. Cages and racks are badly rusted.

The specimen collection is in a very disreputable condition, which has been worsened by very humid conditions. Proper curation of study skins, skulls, and other specimens should be an assigned responsibility for one of the staff. Better storage cabinets plus appropriate air conditioning are needed. Additional office and laboratory space will be needed.

A skin collection of small mammals for taxonomic purposes apparently is lacking in Bangladesh. Therefore, VPS has an opportunity to make a real national contribution, since many environmental studies and surveys depend upon data repositories to provide identification and distribution data.

The library, now approaching 2,000 units, also needs attention. A clerk with some instruction could initiate some organizational efforts. These housekeeping matters indicate the kinds of choices that sometimes must be made. With limited manpower and heavy field demands, efforts are focused outward; consequently, laboratory maintenance and equipment inventory activities get postponed.

Long-term institutional needs obviously focus on administrative independence as well as cooperation, appropriate training of personnel, and current reinforcement of professional skills. Traditionally, academic institutions have not considered administrative training an important element in graduate education. However, the students enrolled in the Colorado State University program get specific experience with research management. Those attending the biannual CSU workshops receive even more attention to this important subject. DWRC might seek additional means of administrative training, especially for the more senior individuals.

In general, the present staff is well-trained, and the current program is well-executed due to the DWRC backup effort. With some additional leadership and technical assistance, the VPS could potentially stand alone and function as a "sister" institution to DWRC.

Many efforts have been made to develop technology that is safe, inexpensive, appropriate, and accepted by user groups, particularly farmers. In evaluating the current large-scale effort at technology transfer, the use of burrow baiting in *T. Aman* rice to maximize rodent population control is an attempt to evaluate social acceptability (as well as technical efficiency) under farm or village situations. Similar concerns are evident in bird-scaring efforts, analysis of jackal behavior, and management strategies for other rodent species. However, interaction with Farm Systems Research and Extension has been limited.

D. Denver Wildlife Research Center Site and Program Review

The site and program review at DWRC was intensive, and formal documentation is very detailed. Information on various aspects of DWRC activities and support to the VPC are presented in Appendixes 1.0 and 2.0. Only a brief summary will be presented here.

DWRC, acting under an USAID-PASA agreement, provides technical backup for VPS. While the original project amendment was signed in 1978, the evaluation team was directed to focus on ARP-II, beginning in 1986. The current DWRC Project Leader initiated planning during TDY in 1985 and was resident by 1986. The work plan emphasized pre-harvest rat damage in rice, post-harvest rodent problems in houses, and jackals as pests (Appendix 7.0).

DWRC's International Programs Research Section (IPRS) coordinates assistance to VPS. This involves provision of equipment and supplies, a variety of information and consultation services, academic and workshop training, and direct

field assistance through TDY. Most of the indirect assistance is provided at no cost.

IPRS can (and does) draw upon the DWRC staff with their diverse professional backgrounds to provide information, respond to needs, and actually go to the project site to assist in conducting training and experiments.

During this period, site assistance has been provided for establishing trapping and monitoring procedures for the predator study. The statistical basis for the rice and bandicoot field tests was developed through on-site consultations; several specialists on TDY will assist with the observations (Appendix 1.0--Section 1.7).

Much information and computational services have been supplied. The VPS has been supplied a working library and, in the near future, will be a direct part of a computerized bibliographic retrieval system. Extensive editorial services are provided as well.

Equipment ranging from computers and animal cages and racks to micro-radio transmitters for telemetry studies have been supplied. A variety of specialized supplies have been provided as well. Recently, chemical analysis of several hundred zinc phosphide samples was completed, since local services were not available.

Academic fellowships have provided graduate-level training for all of the staff. DWRC facilities have been used, and the staff has played a major role in advising and teaching the project participants at CSU.

E. Environmental Impact

Documents on environmental concerns, including integrated pest management (IPM), rarely, if at all, mention rodenticides and rodent control pesticide misuse. The rodenticide recommendations were developed in close consultation with DWRC, which has quality expertise available in analytical chemistry, toxicology, pesticide registration, and laboratory practices. In addition, one DWRC section has responsibility for coordinating field and laboratory test data for submission to U.S. Environmental Protection Agency (EPA) for label registration.

The two rodenticides selected for use in this fall's field trials are phostoxin (a fumigant) and zinc phosphide (an acute rodenticide). Both are labeled for use in rodent control in the U.S. and are standardized (i.e., registered) in Bangladesh. Both are to be used in environmentally suitable regimens.

Both toxic materials will be placed in burrows and the entrances sealed, thus preventing accidental poisoning of nontarget species. The fumigant degrades quickly when exposed to air. Zinc phosphide similarly degrades when exposed to moisture. Neither chemical results in secondary incidents, even if the carcass is found and eaten by a scavenger.

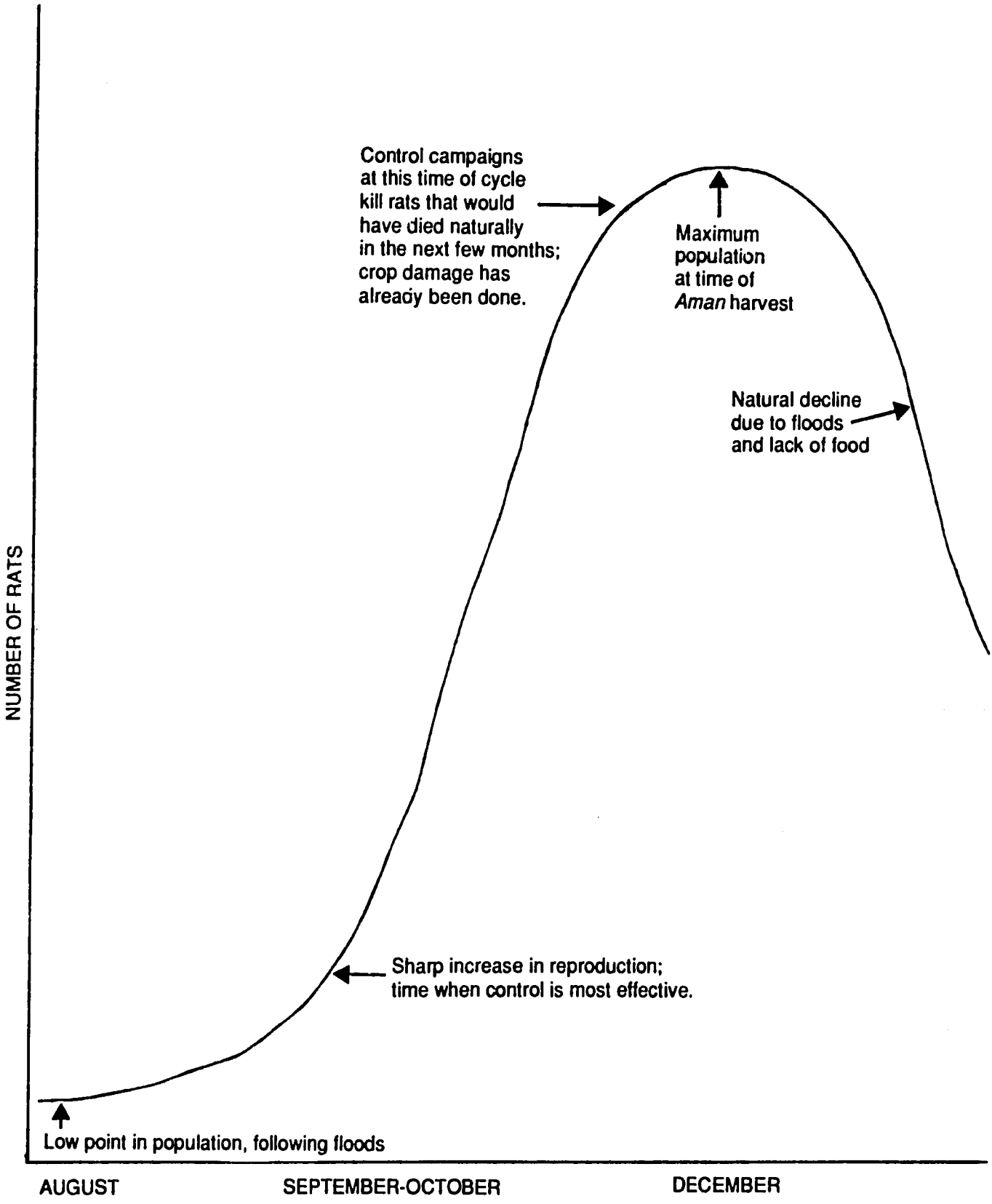
This fall's experiments utilize a single annual placement of toxicants rather than the several that have been recommended in the past. Consequently, the total amount of rodenticide placed in the environment is considerably reduced; and the time of placement, just as food availability and reproduction have greatly increased, is calculated to maximize long-term population reduction. These components are fully in keeping with IPM principles. (See recommendation #10; Alcorn and Johnson 1989.)

The pesticides will be applied directly by VPS staff or by farmers specifically trained by the staff. During these experiments, DAE and FSR personnel will be observer/participants rather than instructors. This direct farmer contact provides VPS with the opportunity to stress both the safe and proper use of the rodenticide materials as well as appropriate use of insecticides, fungicides, and herbicides.

In addition to its basic review of rodenticide usage, the evaluation team was asked by the USAID/Dhaka Project Officer to review the VPC research activities relative to the issues being raised by an USAID Environmental Assessment Team, which was then in Bangladesh preparing a final report (Showler 1989).

While the team noted that no studies of pesticide effects on mammalian wildlife had been undertaken, this rodenticide application pattern does not create any such hazard. Showler (1989) also lists several "IPM tactics", including giving prizes for killing rats or payments for collected rat tails. Such efforts may attract publicity but are of little value in reducing rat populations, since "rewards" are offered at times when rats are at maximum numbers, and most would die from natural causes anyway (i.e., fighting, starvation, and/or disease) (Figure 1).

Figure 1. **Bandicoot Rat Population Schematic.**



Another suggestion has been the baiting with chemosterilants; however, none is available for use. Traps or burrow flooding could be used, but these are time-intensive methods. Furthermore, the most common rat species does not readily enter traps. Other suggestions have included environmental enhancement for raptors with installation of perches and/or nesting boxes, but these remain unevaluated, even in other countries.

Predator Control

Jackals are the most numerous predator species. Early VPC surveys of farmers found that important losses of sugarcane and poultry were credited to jackals. On this basis, predation studies were given priority in the work program.

Preliminary efforts, aided by DWRC consultants, determined the feasibility of using radio telemetry to study jackal movements. Current studies are documenting food habits and behavior, and a census technique is being developed. Additional telemetry studies are planned for next year.

The initial analysis of the current collection of food habits data suggests that the jackal may be a favorable species in the ecosystem (Sultan and Jaeger 1989). As predator, it may have a controlling effect on rodents. In this respect, its value may be greater than losses of cane (which may be less than originally estimated) and fowl; consequently, jackal removal might be counterproductive. Population models are being developed for future testing.

Relative to another aspect of environmental quality, "Congress charged AID with preservation of biodiversity in all its development activities" (NRC 1989). The fact that maintenance of environmental biodiversity (i.e., retention of jackals and other predators) might result in lower rodent populations needs to be considered further. The present mandate to foster this environmental relationship is consistent with the continuing jackal studies.

F. Rodenticide Quality

Early GOB rodent control campaigns have faltered when the farmer was required to buy zinc phosphide on the open market and mix his own bait. When the rodenticide was deteriorated and/or adulterated, the placed bait was ineffective; the farmer concluded the whole program was useless.

That the farmers were able to discriminate was testified to by one DWRC team leader. The campaign had used zinc phosphide baits formulated and provided to farmers by the VPS that were

highly effective and which sold at a nominal cost. Following the campaign, farmers refused to buy zinc phosphide on the market (and thus carried out no rat control) but, whenever possible, attempted to buy bait from project members when they were in the field.

A recent analysis of zinc phosphide available in local markets was completed by the DWRC. Nineteen of the 21 brands collected tested well below required quality and would have been ineffective in control efforts (Appendix 10.0).

There is one authorized importer of technical zinc phosphide, which is redistributed by five dealers within Bangladesh; but product control seems to be lost at that point in the system. It is suggested by these dealers that zinc phosphide smuggled into Bangladesh may be a source of substandard baits.

The evaluation team strongly believes that a program to validate the zinc phosphide on the market be instituted prior to any future public campaign in which the farmer must buy the control material. This could be done under PPD as a regulatory procedure (requiring additional laboratory and enforcement personnel). Alternatively, private (entrepreneurial) groups such as local women's associations (with technical and managerial assistance from a NGO) might market and guarantee finished baits under a certified trademark. Some means of assuring rodenticide quality is urgently needed if the rat control skills being taught to farmers and extension personnel are to have future value.

While VPS is formulating and distributing zinc phosphide baits to participating farmers for the Fall 1989 field test, and might continue to prepare baits in the future, this is not recommended as it would be inappropriate and counterproductive in the long run by drawing resources away from research efforts.

G. Vertebrate Pest Section Interface with Farming Systems Research under ARP-I and -II

Interface under ARP-I

During ARP-I, the VPS established numerous linkages with relevant Bangladesh agriculture institutes and NGO extension activities. A technology delivery system to the Bangladeshi farmer was assured for several years during the early years of the project through extension support from GTZ and FAO. In particular, FAO and GTZ provided organization and funding for the national rat control campaigns which used the VPS-developed technology. GTZ sponsored a mass media communication campaign and achieved notable success in creating farmer awareness of

control strategies plus the use of a locally formulated rodenticide.

The momentum of this extension effort was lost with the termination of GTZ and FAO project activities. Farmer confidence in the recommended zinc phosphide baits declined due to lack of quality control in bait formulation. The larger ARP-I project-related Extension/FSR activities during this period were notable for their lack of interaction with the VPS.

Interface under ARP-II

During ARP-II, attempts to involve FSR in vertebrate pest problems were not successful for a variety of administrative and technical reasons:

- lack of an umbrella FSR coordinating contractor for much of the tenure of the present DWRC Project Leader (1986 to 1989). During this period, interest, enthusiasm, and the opportunity for incorporation of FSR in project activities declined;

- two changes of USAID project officers since 1986 which led to discontinuity of management oversight on integrating VPS activities into FSR and extension under ARP-II;

- no provision in the VPC work plan starting in 1986 for intensified linkages with FSR. However, it did plan for a large-scale on-farm testing activity to be carried out after preliminary applied research had finished;

- no provision in the DWRC research protocol for the integration of FSR in the early stages of applied research. The initial identification of effective vertebrate pest management techniques for the control of rats in rice had to be based on objective scientific information. This premise demands that, in the early research stages, the investigator must have control over all aspects of the study. The control required made farmer participation undesirable at this stage. However, once a technology package appears feasible, it is important to field-test under actual farming conditions. It is also necessary to evaluate technology effectiveness under a farmer management system if the technology is to be accepted. This professional premise did not provide for an integration of FSR during the early stages of technology development;

- the fact that under ARP-II, FSR's concept of Integrated Pest Management has not considered vertebrate pest management as a part of the normal organizational pattern which includes invertebrate pest control and plant pathology. There has been a trend to consider it as distinct. This professional equivocation will have to be resolved before a complete integration can be achieved.

Activities to Improve Vertebrate Pest Section Integration with Farming Systems Research under ARP-II

There have been a number of recent initiatives to improve FSR/VPC integration. The most notable of these initiatives are:

- the chronology for research implementation has been strictly adhered to and, as per the research plan, includes implementing a farmer testing phase. This field test includes the integration of the ARP-II prime contractor's FSR personnel and regional, site-specific Bangladeshi FSR personnel;

- a workshop held in May 1989 at the request of USAID discussed the research results of the applied vertebrate field and laboratory tests (Appendix 11.0). There also were preliminary discussions on the proposed field research phase, which includes large-scale farmer testing;

- as a spin-off from this workshop, a National Committee on Vertebrate Pest Research was established. Part of its mandate is to serve as a coordinator of VPS and FSR adaptive research activities (see Appendix 4.0);

- the large-scale farmer testing of the VPS' technology package starting in September is an excellent opportunity to bring VPS senior scientists and field technicians together with their counterparts in the overall ARP-II FSR component. The location of the VPS testing sites in Ishurdi and Comilla is contiguous with those multilocation sites of BARI's FSR program. This geographic proximity should facilitate greater professional exchange; and

- the research protocol for the VPS large-scale testing of rat control technology and farmer implementation will be a prime source for the kinds of data required by FSR to integrate rat control technology into existing cropping of *T. Aman* rice. It also provides FSR the information to adjust

recommendations to the five categories of producers found at their multilocation testing sites. The objectives of the VPS field test can address questions about the cost-effectiveness and acceptability of application methods, as well as identify major socioeconomic and institutional constraints. (See Appendix 6.0)

There are a number of actions which could be taken by ARP-II FSR program personnel to increase the interaction between VPS and FSR, including:

- the existing BARI FSR data base for the proposed VPS testing sites should be consulted by the VPS field research team as a secondary source of production information, particularly existing socioeconomic profiles of farmers in the area;

- an arrangement should be made to second an FSR agronomist full time for the duration of the on-farm study to the VPS field study team for the area. This individual should participate as an in-service trainee in all aspects of the field study. He should participate fully in all aspects of the integration of the Rat Control Strategy--particularly in training farmers in rat control methodologies; and

- the VPS' on-farm trial presents a unique opportunity to collect and analyze economic information on vertebrate pest management. The VPS may be able to hire a Bangladeshi agricultural economist, skilled in collecting data at the farmer level in Bangladesh, through the Winrock Human Resources program.

Over the remaining project period, an intensive effort needs to be devoted to the socioeconomic analyses of vertebrate pest management strategies. Some of the most urgent information required is:

- accurate quantification of actual rat damage pre- and post-harvest to the most dominant subsistence grain crops in both financial and economic terms. This information should respond to the needs of the small-scale producer and national planner;

- social/cultural analyses of farmer participation in recommended vertebrate pest management studies. This analysis should focus on social and/or religious constraints to farmer acceptance of recommended management practices; and

- analyses of the effectiveness of distinct communication techniques in persuading the Bangladeshi farmer to implement recommended pest management strategies.

The staffing and implementation of the VPS research mandate cannot provide this type of social/economic leadership for the long-term. However, since the type of socioeconomic information required is so critical over the next two to three years, it would be useful for part-time consultants to be brought in to provide the specialized analyses required and provide training to selected scientists in the VPS and existing socioeconomic researchers assigned to FSR and DAE.

Socioeconomic intervention required:

Field Economist	4 p/m x 2 years
Socio/anthropologist	3 p/m x 2 years
Communication Specialist	3 p/m x 2 years

Existing Vertebrate Pest Section Extension Activities

Since 1978, the VPS has consistently worked with the DAE in order to maintain critical linkage with the farmer and to provide extension activities with needed information on pest management. The following is a list of the types of direct extension interventions that VPS conducts:

- participates in evaluating the two rat control programs each year conducted by the DAE. This requires three to four days in the field; following each campaign, there are pre- and post-campaign meetings. Since 1988, DAE has been provided with VPS recommendations;

- an average of eight radio programs are given per year about vertebrate pest problems and control techniques;

- an average of four magazine articles are published per year in "Krishi Katha" and "Adab Sangbad" on vertebrate problems. These are popular (mass media) articles in agricultural periodicals;

- regular displays at BARI prepared by the VPS on vertebrate pest problems for a wide variety of visitors. The VPS also has prepared displays for a variety of other gatherings (e.g., the Science and Technology fair in Dhaka and National Rat Control Campaign 1987); and

- participation in a variety of training courses for:

  -- block supervisors and students at AETI/DAE (Agricultural Extension Training Institute) training courses,

  -- district-level plant protection officers (SMS) and senior instructors of AETI, and

  -- Farmer's Day Program at BARI field stations (Appendix 2.0).

H. Human Resources

Management Training

The formal degree training program supporting the VPS has been well-focused and has provided a well-trained group of scientists at the M.Sc. and Ph.D. levels. As the VPS matures in experience, new candidates for research and administrative leadership will be required. The existing group of senior scientists who remain in the VPS should be given the opportunity to receive specialized management training. This should also be considered for those just starting the post-graduate training (see Appendix 9.0).

Depending on the availability of resources from the existing International Service for National Agricultural Research (ISNAR) and Winrock Human Resources contract, the VPS should access the experts for advice on suitable institutions to provide the kind of management training required by the VPS. Also, the DWRC has close ties to the USDA OICD training facilities which offer courses in research management. This should be explored by the DWRC Project Leader.

The VPS is essentially a field-oriented research unit with specialized procedures and equipment required to carry out its mandate. The ties to the DWRC center in Denver, Colorado, give the VPS an opportunity to upgrade its field technicians either by DWRC-sponsored in-country training or courses offered at the Center in Colorado.

Within the VPS, periodic in-service training can be organized, and the ARP-II human resource development specialist should be consulted to provide guidance in the design and planning for in-service training within Bangladesh. ARP-II has scheduled training in the use of CD Rom data base for various agencies in BARC and BARI. The VPS personnel should be included

in such training, since the newly available bibliographic retrieval system utilizes this data base.

Women in Agricultural Development

Women play an important role in the agricultural sector of most developing countries. Yet, it has only been in the last decade or so that the nature and significance of their contribution has been acknowledged. The influence of *purdah* or veil and the restricted mobility of women have provided the basis for a clear division of labor between men and women in rural households of Bangladesh. While men primarily engage in production and marketing activities, women engage basically in homemaking. In fact, the rural women in Bangladesh represent vital human resources. Many projects and programs have already amply demonstrated that, given the opportunity, rural women can be mobilized, organized, and trained to make significant contributions to the national goal of food self-sufficiency and food security. In agricultural activities, although contributions may be made by women during the pre-harvest, harvest, and post-harvest periods, a woman's most important responsibility is associated with the transformation of agricultural crops. Some of these activities are: drying, stirring, cleaning, threshing, winnowing and storage of the rice; cleaning and preparing wheat, mustard, and pulses for storage; and extracting and drying jute fibre.

The data collected by the USAID/Dhaka 1989 Agriculture Sector Review includes a section on women in agriculture which confirms that there is considerable variation in women's involvement in agriculture in the different households. The highest involvement of women in agriculture is focused in very small households (0.05 to 0.49 acres). Despite a widespread belief that women are not involved in field agriculture, the data indicate women's active participation in field agriculture--especially in small households, followed by medium size and very small households.

Although estimates are not available, post-harvest losses due to mouse and rat damage in grain stores in farmers' houses are considerable. Rural women have demonstrated a resourcefulness that may be profitably utilized for rat control in the house and perhaps in the field. In the rural situation, rats may be controlled in the house directly either by trapping or baiting. Different types of traps are available and, if properly trained in their use, women will be able to trap rats in household grain storage. The most commonly available rat poison in Bangladesh is zinc phosphide. With appropriate precautionary measures, zinc phosphide baits can be used for killing rats. However, as rat control in one house or grain storage area does

not solve the problem, such control needs to be undertaken on a community-wide basis.

Buying traps and rat poison involve some amount of expenditure. The VPS has proposed that funding could be provided by the Grameen Bank to regional women's groups to finance the regional fabrication and sale of zinc phosphide rat baits. The proposal assumes that regional women's groups could be more responsible in the processing and formulation of rat baits than is the case with large urban bait formulation. In fact, the Grameen Bank has become the largest program providing institutional support to rural, poor women (Hossain and Afsar 1988). The type of women's groups created by the Grameen Bank have many advantages, such as flexibility and freedom from bureaucratic procedure. The cooperatives also offer attractive features for the organization of rural women, such as a legal entity and visibility, and assure better integration into the mainstream development programs.

At present, very few women scientists are engaged in agricultural research in Bangladesh. The resolution of gender issues is crucial for the agricultural research system to become more responsive, particularly to the needs of women farmers.

Women scientists have amply demonstrated their ability in agricultural research. One Bangladeshi woman earned her Ph.D. in Wildlife Management in 1985 from the Colorado State University through the project and has been serving as a Senior Scientific Officer in the Vertebrate Pest Section of BARI. She has been deeply involved in pre-harvest rat damage and control research in the field and has already authored and co-authored an impressive number of technical reports and publications. Her field research sites included transplanted *T. Aman* rice agroecosystem and the broadcast deepwater *T. Aman* rice system. Her research required travel by country boat and gaining entry to small farmer households. Given opportunities and incentives, it is believed that more women scientists will be attracted to agricultural research.

I. Institutional Sustainability

The issues that make up the concept of sustainability are complex, somewhat unsystematic, and in most cases, require experience-related judgments. This evaluation makes many such judgments about VPS' sustainability. Major issues that affect the sustainability of the VPS are:

- the ambiguous administrative position of the applied field research-oriented VPS in a discipline-oriented Entomology Division of BARI;

- the critical role of good research management in providing a creative work environment for the personnel of the VPS;

- the importance of a stable yet administratively flexible financial allocation of resources to facilitate the field-oriented research effort; and

- the importance of strong working linkages between the proposed Vertebrate Pest Management "Division" and the existing Farming Systems Research Division within BARI.

The first issue affects the sustainability of the VPS within the Entomology Division of BARI. This is not a unique problem for vertebrate research. In other research institutions, it rarely fits into a traditional Entomology or IPM department. The educational development of the VPM scientist is often different from that of an entomologist. The applied field-oriented approach of its scientists distinguish them from the strict disciplinary orientation of many surrounding researchers. This conditions the attitudes of administration and scientist alike with a small group of VPM scientists surrounded by a large group of IPM entomology scientists, which may not be the most creative working environment for the VPM researcher. Such attitudes inhibit the cross-fertilization that results from the exchange of ideas.

The second issue of good management is one of the most important features of any good research division. Currently, within the VPS, there is the need to assure that adequate leadership will exist after the departure of the DWRC Project Leader. The existing Bangladesh VPS team has this capacity for leadership. However, within the time remaining, a critical review of any gaps in required leadership skills should be carried out and appropriate training actions taken. Those candidates currently doing their graduate studies abroad will receive some research management as a normal part of their curriculum. However, this can be augmented through specialized training given at several institutes in the USA and Europe.

The third issue concerns the importance of financial stability both within BARI and in the routine operation of the VPS. In the wider sense of the VPS in BARI, a great deal will depend on its research performance and the possibility of its becoming a division apart from the Entomology Division. The BARC will have to create a separate budget allocation with a stable source of funding to assure the future of VPS. BARC has indicated its willingness to do this under the next five-year plan beginning in 1991.

The current funding of VPS is in a period of transition between total access to USAID project funding and greater reliance on PL 480 funds. This transition period will require particular attention to avoid difficulties in funding essential final-phase testing of recommended technologies. There are minor and, perhaps, major delays in accessing PL 480 funds. In some cases, these delays are due to an unfamiliarity with the new procedures required to solicit and disburse these funds--both on the part of BARI and the VPS. USAID should note that appropriate training apparently is needed for users of this new accounting system and should take the necessary measures to ensure suitable use of the funds.

The current organizational pattern within BARI can be described as containing 10 disciplinary-oriented research divisions and one field-oriented research division. If the VPS is granted division status in the near term, and if the program of activities intended to create and strengthen linkages between the vertebrate pest management research program and the FSR program are pursued in earnest over the near term, then it can be expected that a synergistic relationship will develop between the two divisions. This institutional synergy can be useful in contributing to the sustainability of the newly established VPM division. Not only will these two divisions share elements of methodological approach, but the actual research agenda of each will tend to rely on the output of each over time.

The sustainability of the recommended rat control technology at the user level is the ultimate test of the Research Process. The essential criteria for Bangladesh are:

- farmer understanding of the technology;
- safe usage of the technology by the farmer;
- recognition that the control measures do not have a detrimental effect on the environment;
- cost-effectiveness of the technology for the particular category of farmer; and
- in-country formulation of the technology.

In the particular case of the VPS' recommendations, all these criteria have been considered in the Research Protocol. The use of zinc phosphide to kill rats in Bangladesh is not new, but the technique for its deployment under project recommendations is innovative.

J. Discussion of Logical Framework Assumptions and Outputs

The complete logical framework for the Vertebrate Pest Component of the ARP-I and -II is included as Appendix 3.0. Briefly, the project component inputs were to include both resident and short-term technical assistance through a PASA with DWRC, facilities improvement, commodity procurement, provision of seminars and workshops, and the establishment of the organizational location of the vertebrate pest unit within BARI. With the exception of the establishment of the vertebrate pest unit as a "section" rather than as a "division" with its own budget within BARI, all inputs to the project component have been provided. With one exception, all outputs of the project component have been achieved. It was assumed that implementation of the project component would result in the establishment of coordinated research between the VPS and research institutes in other countries with expertise in VPM. To date, the coordination has not occurred because of the lack of sufficient research and development results. With the final phase of the project component and the farmer implementation trials this fall, it would be the ideal time to initiate contacts with regional vertebrate pest management programs, perhaps in the form of a regional workshop.

However, there are certain important assumptions of the original logical framework which deserve discussion here. It was assumed that in order for the component to achieve its goal, there needed to be adequate linkage between research activities of the project and extension programs in the area of plant protection. In the particular case of ARP-I, this assumption was valid as long as the GTZ and FAO projects were in place, because these project activities served the extension function. However, when these projects were terminated, the linkage had not yet been institutionalized within the VPS. There continues to be informal cooperation between VPS and DAE, although at a lesser level of intensity due to the lack of support from the external agencies. In the early stages of ARP-II and until recently, the linkage was weak due to a strict VPS research agenda that left little time for VPS to improve this linkage.

It was assumed that in order to achieve the purpose of the project component, there would be adequate interest in vertebrate pest problems within the BARI to assure cooperative efforts and support in developing an ongoing research capability in the area of vertebrate pest management. An important element of the purpose statement was the establishment of a Vertebrate Pest Management Division. The divisional status was not achieved. As a section of the Entomology Division, the initiative and support for the VPS was limited on the part of BARI--in part, because much of the VPS research was off-station and did not fit into the traditional administrative norms of the Entomology Division.

It was also assumed that in order to reach the project component purpose, the research program, based on currently available information, would not require significant modification such as more detailed information on the nature and extent of vertebrate pests. Additional research during ARP-II did, in fact, indicate the need to examine the level of rat damage in *T. Aman* rice rather than strictly in wheat and to re-examine the role of jackals as depredators and predators. This type of modification would be considered normal for most off-station research programs.

The remaining assumptions related to the Vertebrate Pest Component, as per the logical framework, are considered valid.

K. Lessons Learned

Constraints to Communication Between Professional Disciplines

There is often an assumption made that there is open communication among professionals of differing disciplines within a research institute, such as BARI. In the particular case of vertebrate pest research, this assumption should be carefully examined. The VPS is a small group of dedicated professional field researchers whose research perspective is different from the entomologists, under whose administrative management they must work. The training of vertebrate pest management scientists covers a diverse set of disciplines and much of the basic research is necessarily conducted in the field. Entomologists within BARI, as within most agricultural research institutions, outnumber VPM scientists, which presents barriers to free communication.

As with vertebrate pest management research, farming systems research is also often perceived by other more established research disciplines as being unscientific and, thus, incapable of resolving the biological constraints to improved production. FSR is a relatively new concept and, in some cases, has been poorly implemented, adding to its poor image. This situation is further compounded by the fact that VPM researchers share a lack of appreciation for FSR with their more disciplinary colleagues within BARI.

During project implementation, periodic exchanges of data between FSR researchers and traditional applied disciplines should be encouraged by research team leaders. The VPS research program incorporates applied fieldwork, which is considered FSR-type research; this may have impeded a free exchange of ideas.

These kinds of internalized barriers should be examined at the project design phase and a mechanism put in place to improve the opportunities for cooperating in common tasks requiring more frequent opportunities for communication.

Basic Research vs. Off-the-Shelf Technology

Development administrators have a pre-conceived notion that basic research is an inordinately long process and therefore, should not be attempted in the context of development projects. The evaluation team frequently heard the expression "Off-the-Shelf Technology" relative to rat control in Bangladesh. Application of existing technology was not an option when the VPC was initiated, nor will it be an option in the future. This is because the specific biological behavior and the environment in which pests live must be studied to determine the most viable control strategy. When basic research is required, scientists should take a collaborative posture and work to build in some easily identifiable bench marks that help administrators judge more systematically the time required to achieve certain research objectives.

Special Nature Vertebrate Pest Service Research in Bangladesh

The VPS has initiated a systematic planning model for the development of field research plans. Their proposed model identifies four important steps:

- define the basic problem;
- identify appropriate control measures;
- develop a strategy for implementation and testing with selected farmers; and
- provide final extension to all potential technology users.

They have proposed that the same group of researchers be involved in all four steps. Very often, the research process is fragmented due to specialization. This results in the conduct of basic research by one set of scientists who, later, place research results in the hands of FSR and extension specialists to obtain farmer recommendations through adaptive research. The advantage of the VPS approach will be the immediate feedback from attempts to implement the recommended technology with selected farmer groups. The VPS research team may be able to reformulate technology in a shorter time frame than would be the case if it were first transferred to a specialized FSR unit.

Synergy Created by the Association with the Denver Wildlife Research Center

DWRC and VPS have, over time, developed an effective relationship, primarily due to clear communication which results in responsive assistance from DWRC for VPS problem resolution. The relationship also benefits DWRC in that the information and questions from VPS stimulate new activity at DWRC, requiring the involvement of many specialists who might not otherwise have had an opportunity to participate.

The professional synergy which has developed between these institutions is not unique to VPS and DWRC. In every case where a developing country research organization has been linked to an institution that has greater breadth of experience and greater research resources, the institutional synergism acts to accelerate the professional maturity of the developing country organization. This institutional development model has been proven successful across cultures and should always be explicitly considered in the project design process.

III. RECOMMENDATIONS

During ARP-I and -II, VPS has performed a highly creditable research task and is now entering an extensive field-testing phase to adapt its research findings to farmer needs. The management strategy for the bandicoot rat in rice, if adopted by farmers, will reduce significantly pre- and post-harvest losses. The socioeconomic evaluation of the Fall 1989 field test will be the critical last phase of this long research and development effort. The Vertebrate Pest Component was initiated for the dual purpose of institutionalizing a research capability within BARI and to enable the development and extension of simple and effective pest control techniques to small farmers.

VPS has developed a field research approach which requires that the same group of scientists, trained under the component, carry through the program fully from the start with basic research on the biology of the rat species, to the adaptation of techniques to the crop environment, and finally, to farmer-initiated implementation. In order for USAID and GOB to fully realize the return on their ten-year investment to date, it is important to allow this research process to continue through its cycle. After successful implementation, the approach becomes a research design model which can be replicated by VPS scientists in future vertebrate pest management research and technology development.

The evaluation team strongly recommends the continued support of the VPS for the ARP supplemental period from 1991 to 1993. To achieve the goal and purpose of the project component, a renewed commitment on the part of the Bangladesh Government and USAID through 1993 will be required. This commitment is not only one of adequate and continued funding, but one of full support for the many evaluation recommendations.

The most critical institutional support and research requirements through 1993 are:

- reorganization of VPS in a separate division within BARI with appropriately trained leadership;
- addition of a farming systems economist (four person-months x two years), a sociologist/ anthropologist (three person-months x two years), and a communications specialist (three person-months x two years) beginning Fall 1989 during the large-scale farmer trials. This specialized assistance will continue to be required as replications of the field test occur or as other technologies are tested over the remaining two to three years;

Previous Page Blank

- strengthening of the National Committee on Vertebrate Pest Research so that program review and coordination occurs and policy guidance is forthcoming on a quarterly basis;

- sponsoring by the National Committee of a regional conference on vertebrate pests and requesting AID and GOB funding assistance;

- funding assurance for at least six person-months of short-term (TDY) assistance annually from DWRC or other institutions to provide specialized technical expertise. Suggested areas include:

  -- research planning, evaluation, and administration, (one person-month/yr);

  -- monitoring of damage and evaluation relative to other cropping patterns, (one person-month/yr);

  -- extension training specific to VPM; (one person-month/yr);

  -- predator movements and effects of predator management efforts on nontarget species, (two person-months/yr);

  -- post-harvest rodent depredations/household storage (one person-month/yr); and

  -- testing of bird-repellent devices and materials (one person-month/yr).

- procurement of specialized research and monitoring (telemetry) equipment unavailable in Bangladesh;

- facilities repair, remodeling, and provision for additional office space and research activities;

- provision of budget resources that need to be readily available to VPS staff to permit ready payment of the transportation, temporary labor, and per diem costs of the frequent and extensive off-station testing required by Vertebrate Pest Management;

- continuation of formal (degree) training, especially in pest bird management, as well as specialized or in-service training, as appropriate. Where it may not have been done previously, management training should be elected; and

- funding for VPS staff participation in regional, national, and international conferences which are another form of training. VPS should be represented in at least one international conference/symposium annually. Travel/training funds needs to continue to be carefully administered to assure that travel contributes to strengthening the Bangladesh vertebrate research effort.

REFERENCES

Adhikarya, Ronny and Heimo Posamentier. 1987. Motivating farmers for action/How strategic multi-media campaigns can help. Shriftenreihe der GTZ 185:1-209.

Alcorn, Janis and Nels Johnson. 1989. Bangladesh Environment and Natural Resources Assessment (draft). Conservation of Biological Diversity in Bangladesh: Status, Trends, and Recommended Responses. Washington, DC: World Resources Institute. 31 pp.

Anderson, J. R., et al. 1982. Agricultural Research II. Report of the May Evaluation Team. BARC, IADC, USAID.

National Research Council. 1989. Evaluation of Biodiversity Projects. Washington, DC: National Academy Press. 50 pp.

Riggs, Fletcher, et al. 1985. 1985 External Evaluation: Bangladesh Agricultural Research Project Phase II (final draft). 215 pp.

Showler, Allan. 1989. Pesticide Use and Environmental Pollution in Bangladesh. Bangladesh Environment and Natural Resources Assessment (draft). Washington, DC: World Resources Institute. 20 pp.

Sultana, P. and M. M. Jaeger. 1989. Control strategy to reduce pre-harvest rat damage in Bangladesh. Bangladesh Agricultural Research Institute, Joydevpur, Technical Report 34.

Winrock International. 1986. Agricultural Research Project Phase II, 1986 Internal Evaluation, Report of the Evaluation Committee. BARC. 276 pp.

Previous Page Blank

APPENDICES

APPENDIX 1.0

DWRC Support Activities

1.1 Participant Training Support and Relationships with U.S. Universities

Training is an important component of DWRC's commitment to establishing indigenous international vertebrate pest research capabilities. Since DWRC began receiving USAID funds in 1967, DWRC has assisted in the vertebrate pest management graduate degree programs of over 50 scientists from developing countries. The first VPS scientist to receive advanced degree training in vertebrate pest management, Dr. Abdul Karim, took a Ph.D. from Bowling Green state University (BGSU) in 1983. As it was becoming clear that the BGSU international training program would phase out, DWRC helped establish a vertebrate pest management program in the University (CSU), Fort Collins, Colorado. One VPS scientist, Dr. Parvin Sultana, has received a Ph.D. in this program; and one VPS scientist, Mr. Yousuf Mian, and one BRRI scientist, Mr. Sayed Ahmed, currently are enrolled in CSU Ph.D. programs. DWRC staff are or have been on the graduate committees of all three of these VPS scientists as well as BRRI scientist, Mr. Sayed Ahmed. In fact, Dr. Karim conducted his research at DWRC field stations in Florida and Hawaii, and both Dr. Sultana and Mr. Ahmed conducted their research at DWRC in Denver. In addition, Mr. Lynwood Fiedler, IPRS Wildlife Biologist, also supervised the M.Sc. research of three VPS scientists at the University of Philippines at Los Baños when he was DWRC Project Leader at the DWRC-supported National Crop Protection Center in the Philippines. DWRC has also participated in establishing a vertebrate pest management class at the University of Wyoming, at Laramie, and is collaborating with Utah State University in Logan, Utah, to implement an international vertebrate pest management degree program.

IPRS staff have organized and participated in a graduate-level course in Vertebrate Pest Management offered at Colorado State University every other year. To date, 52 students have participated, including Dr. Sultana; Mr. Mian is expected to participate in the next course. In addition, the 1st International Short Course in Vertebrate Pest Management was instituted in cooperation with CSU in 1987; 21 individuals from 12 countries attended; the 2nd Short Course is being offered in August 1989, and Mr. Mian and Mr. Pandit will be participating.

DWRC is committed to an international training effort in vertebrate pest management. However, the DWRC is an U.S. Government research laboratory, not a training institution *per se*. DWRC does not have an international training coordinator; and at the current low IPRS staff and funding levels, it cannot

increase (despite increasing requests) its already intense cooperative training associations with U.S. universities. DWRC and CSU are trying to meet these requests on a piecemeal basis. Priority for hands-on training experiences are given to scientists from project field stations, yet it is imperative that support is obtained to coordinate the many short- and long-term international training requests DWRC gets each year. CSU and DWRC have prepared a proposal for support of a four-year 1PA to base an individual at CSU to develop and coordinate this effort. CSU hopes to carry the cost of this position at the end of four years. If this proposal is funded, DWRC will continue and will expand its cooperative role with CSU in international vertebrate pest management training.

Over the years, a number of Bangladesh scientists and VPS-related individuals also have visited DWRC. Opportunities continue for such visits and for hands-on training in specific technical areas at DWRC for several graduate students. Several such informal, hands-on training experiences for project scientists have occurred or are being planned. An opportunity was provided in May and June 1989 to Mr. Yousuf Mian to work with DWRC scientists from the Section of Mammal Damage Research in a field trial to evaluate the efficacy of strychnine formulations on pocket gophers. Plans are being formulated for Mr. Rajat Pandit to work with DWRC predator specialists in Logan, Utah, on coyote management, and for Dr. Parvin Sultana to obtain SAS training and then begin analyzing the data from the 1989 pilot rodent control demonstration at DWRC.

The professional training opportunities have resulted in a well-trained scientific professional cadre. However, two areas that need additional attention are those of paraprofessional and support personnel, areas that DWRC recognizes as integral to maintaining a research institution, and training areas which should be easier to provide within the new ARP-II Umbrella Project. Specific training needs should be identified in these areas, and current or new project counterpart staff should be appropriately trained to fill those needs. With DWRC's transfer into USDA by a Congressional Act in 1985, DWRC may be able to assist with its access to some USDA programs that might help fill these needs. For example, the Training Division in the USDA Office of International Cooperation and Development offers skills training for foreign professionals either in the U.S. or in the home country. Two OICD courses that might be appropriate are Management of Agricultural Research and Designing and Managing Agricultural and Rural Development Progress. A variety of other less specialized training courses such as driver training, safety and health, word processing, video preparation, and accounting, to name just a few, would be very worthwhile investments for project staff and would help ensure institutional maintenance of vertebrate pest management research capability.

1.2 Printing, Reproduction, and Related Information Services

The IPRS has participated in preparing final copies of numerous VPS documents. Thirty-five scientific publications and six graduate theses have resulted from this Vertebrate Pest Component. Another 116 related scientific publications and research documents that have influenced the research direction or are applicable to the Bangladesh pest situation have been generated under USAID support, without cost to AID/Dhaka. Most of these documents have been prepared by the IPRS Editorial Assistant, received professional scientific peer review by DWRC scientists, and were published only after approval by the DWRC Director. The IPRS Editorial Assistant also has initiated reprint orders and has been involved in preparing 37 Technical Reports, 11 Annual Reports, and 23 Technical Assistance TDY Trip Reports. All reports and manuscripts were prepared on WANG equipment through 1988 and on an AT&T 6300 with a laser printer during 1989. This equipment is compatible with the computer recently installed at the VPS, with the hope that DWRC and the Project will be able to transmit documents directly. Only Annual Reports are printed through the Government Printing Office (GPO).

The paper communications network established and maintained by DWRC with Bangladesh is working well. Cable messages can be sent through OICD. In addition, DWRC has a direct dial telephone capability and its own telemail, telex, and FAX capabilities. As previously indicated, IPRS is currently setting up to implement a compatible computer capability to assist in transferring data and documents. DWRC regularly uses these facilities to maintain international communications with Project field stations in Bangladesh, Pakistan, and AID missions around the world.

1.3 Procurement Arrangements

Funds are retained in the IPRS to purchase and ship supplies and equipment to the Vertebrate Pest Section. The Project Leader and counterpart staff prepare lists of equipment, materials, and supplies that cannot be purchased in Dhaka and provide these lists as needed throughout the year to the IPRS Section Chief at DWRC. For any specialized equipment, the IPRS Section Chief consults with the scientists at DWRC to obtain the best source of supply and most appropriate type of equipment to meet the Project requirements. Between 1979 and 1988, DWRC backstop support personnel ordered or purchased, repackaged, and arranged to ship more than 15,000 items in over 500 shipments. The items ranged from basic office supplies to anesthetizing agents, rodenticides, radio transmitters, and 6' x 3' x 5' galvanized animal testing racks and cages. All items have been purchased in accordance with USDI or USDA procurement Directives and have been shipped by USAID pouch, Overnight Express, Flying Tigers (in the case of pesticides), or ocean freight (in the case of animal testing equipment). Items are sent with a notice of receipt, which is

signed by the Project Leader, returned to DWRC, and filed. Because the IPRS Section Chief (and others of DWRC staff) are able to undertake these procurement activities, major efficiencies are secured for projects. While some purchase and shipping costs are covered by Project funding, the greater value of the backstopping effort is considerable but little realized.

Under USDI, in general, all items with a value of $100 were put on a U.S. Government inventory list and accounted for each year by the Project Leader; under USDA, only items >$500 must be inventoried annually. However, a few specific sensitive property items, regardless of cost--such as two-way radios, small office machines, cameras, and binoculars--must be included on inventory. In the past at least, this information also was provided to AID/Dhaka. The IPRS Section Chief participated in Vertebrate Pest Section inventories during TDYs in 1987 and 1988. Inventory lists are maintained both at the Project site and DWRC.

The DWRC Research Support Section also provides a variety of non-USAID-funded services to the international community, in general, and to the Bangladesh project, in particular, through literature searches, interlibrary loan/document delivery, current awareness, monograph/journal purchases, publications distribution, international training, and visual displays. The annual cost to maintain these capabilities at DWRC is about $60,000.

1.4 Interlibrary Loan and Report Production

On-line bibliographic searches are done on various commercial databases (BIOSIS, AGRICOLA, CHEMICAL ABSTRACTS, AGRIS, ZOOLOGICAL RECORD, etc.). Recent literature reviews have been done on wild pigs, jackals, quelea, rodents, porcupines, and parakeets, several of which have been acclaimed as pests in Bangladesh. Because most commercial data bases begin in 1970, manual searches also are done to find older material to complete the research project requirements. The end product is a bibliography with abstracts. The DWRC library is part of the National Agricultural Library Document Delivery System. Any articles, books, or reports requested are located through this system for copying or loan. The library also uses several electronic mail document delivery services with the British Library and other vendors to locate obscure material not readily available in the U.S. Most of the more than 1,500 reprints currently in the Vertebrate Pest Section Library at BARI were provided through the Information Services Project. Tables of Content from journals or actual journals received at DWRC are routed or provided to IPRS field stations. The Bangladesh field station currently receives Tables of Contents from two journals, Current Contents-Agriculture and Current Contents-Life Services, and actual volumes of the following 13 journals as they are published:

J. of Applied Ecology,
J. of Bombay Natural History,
J. of Field Ornithology,
J. of Mammalogy,
J. of Wildlife Management,
Northeastern Bird Banding,
American Naturalist,
Animal Behavior,
The Auk,
Crop Protection,
Ecological Monographs,
Ibis, and
J. of Animal Ecology.

The DWRC Library processes all book orders under a U.S. Government blanket purchase agreement. Because of its status as a government library, it is able to take advantage of discounts and locate free copies of many items. The Bangladesh field station subscriptions are included in the DWRC combined annual orders. The VPS Library has about 100 such volumes that have been ordered through the DWRC library. Foreign scientists visiting DWRC through the IPRS receive a great deal of assistance from the DWRC Library available to them. Yousuf Mian, Parvin Sultana, and BRRI scientist, Sayed Ahmed, all have made extensive use of these services while in the United States. DWRC Information Services staff have prepared hallway panels of photographs and text as part of a current awareness project for DWRC. A panel on post-harvest losses in Bangladesh was displayed at DWRC for several months before being sent to VPS for use.

With additional funding, DWRC Informational Services could better interrelate with the international research community through the creation of data bases and the use of CD-ROM technology. First, the Bangladesh field station could have a microcomputer data base catalog of books, reports, slides, photos, and reprints located there. The data base management software being used at DWRC is Pro-Cite. The Pro-Cite software is easy to learn and use, and the data bases can be subject and keyword-searching, customized bibliographies, and authority lists to standardized entries. By standardizing the program and formats used at both DWRC and its overseas field station, compatibility problems are eliminated, and sharing of resources is enhanced. Second, most of the IPRS field stations are located in countries where both electrical power and telephone linkups are unreliable. An alternative to direct on-line searching of commercial data bases (which is costly and requires dependable telephone lines) is the purchase of the CD-ROM data base technology. The only additional equipment required is a CD-ROM player which is cabled to the microcomputer. There is a one-time cost for purchase of the data base and an annual subscription for the updates. An optical storage system for archival documents is on order.

1.5 Analytical Services

The DWRC provides considerable analytical and bioelectronics services to the Bangladesh Project, yet no USAID funds from any source directly support these activities. The DWRC Statistical Services and Research Project provides the staff of DWRC with analytical statistical consultation in all aspects of statistical theory and experimental design; statistical review and assistance with pre-research work units and final manuscripts; data analysis and interpretation; statistical computing and software development; and statistical research related to the current and future research programs of the Center. The Computer Services Project provides the valuable capabilities needed in conducting research programs, as computers provide the only feasible method to handle large masses of data or to extract appropriate research results from them. Computing is used in all phases of the DWRC research program, from initial literature search and study design through data acquisition and analysis, to the final publication. This project provides the staff of DWRC with computer services in the following areas: building statistical data bases, performing statistical computing, planning, constructing, and maintaining special data bases; writing and/or modifying computer programs; training and consulting; and acquiring computer services and equipment.

Personnel in the Statistical Services and Research Project have directly assisted the Bangladesh Field Stations and BARI in a variety of ways during the past several years, including providing: guidance in developing statistically valid study protocols for research trials, advice on statistically sound research designs, and sampling procedures used for work plans; and advice in the analysis and interpretation of research data. More specifically, previous statistical analytical support has been provided to the following Project studies:

FY-80:
- Reviewed Poché manuscript on rodent damage to wheat.
- Reviewed Poché manuscript on rice yield reduction using simulated rat damage.
- Reviewed Poché manuscript on effectiveness of four rodenticides in deep-water rice.
- Reviewed a technical report concerning potential analytical methods.

FY-83:
- Assisted in design of study protocol by LaVoie on post-harvest grain loss to house mice.

FY-84:
- Calculated confidence limits for Brooks' rat trapping data.
- Analyzed LaVoie's data on contamination of stored wheat by house mice.
- Assisted in design of a second study by LaVoie on post-harvest grain losses to rodents.

FY-85:
- Analyzed bird repellency data from two chemicals to three species for Sultana.

FY-89: - Reviewed study protocols on a toxicant delivery system using rodent grooming behavior for Ahmed.

In addition, Statistical Analytical Services has consulted with each field station leader (Poché, Brooks, Jaeger) whenever they were in Denver; on numerous occasions with Dr. Karim and Dr. Sultana on the design, analysis, and review of their Ph.D. research; and, more recently, with Mr. Ahmed, on the experimental and analytical designs for his Ph.D. studies. The analytical expertise of this section will be used even more as the massive quantity of data collected on pre-harvest rodents, jackals, and the upcoming control pilot study begin to be analyzed.

Analytical research also conducted by this DWRC Project also indirectly supports DWRC field station study designs. Two appropriate examples follow:

- Animals used in chemical registration experiments are frequently obtainable only in small numbers, but the statistical properties for small bioassay designs have been largely unknown. A study of the properties of various bioassay estimation methods, using computer simulation for a number of small sample designs, has resulted in a description of small sample properties of these bioassay estimators and recommendations on small sample experimental designs. This research directly affects studies such as LD50 or R50 of bird repellents in Bangladesh.

- Quadrat sampling is often very arduous and costly for estimating densities of objectives. Field studies and computer simulation of plotless density estimators (PDE's) models, developed in collaboration with the DWRC/Hilo, Hawaii Field Station, have resulted in a PDE estimator that saves considerable time, money, and manpower in actual use and has direct applicability for damage assessment studies, such as rat- or jackal-damaged sugarcane in Bangladesh.

1.6 Computer Services

The DWRC Computer Service Project has state-of-the-art IBM compatible Automated Data Processing equipment valued at about $1,000,000. The equipment includes, among others, AT&T 6386's, AT&T 6300's, and laser printers to service DWRC scientists and field stations in the areas of building statistical data bases and performing statistical computing, planning, constructing, and maintaining special data list, DWRC literature data bases, documenting computer programs and packages, instructing DWRC staff in use of equipment software, handling all ADP procurements and billings, consulting and trouble-shooting for IPRS and field

stations, and installing and maintaining all ADP hardware and software at DWRC.

The Computer Service Project personnel have specifically assisted the VPS project in:

- ordering computer equipment that is compatible with DWRC equipment,
- providing training to the Project Leader in establishing SAS data bases,
- putting together a comprehensive SAS training program fora VPS scientist in the United States,
- determining the feasibility of finding SAS training for VPs scientists in Asia,
- providing computer training to IPRS scientists and support personnel (and to Mr. Sayed Ahmed, BRRI Scientist),
- developing an international mailing list data base from which relevant individuals in Asia can be accessed for information distribution, and
- generating all graphic figures for the Bangladesh Project's contribution to the IPRS Annual Report during the past several years, and the graphs and figures for the latest Project Technical Report No. 35.

1.7 International Travel on Technical Assistance Projects by Personnel

Date	Name	Purpose of visit
1979/Jan 8-29	J.W. DeGrazio	Review current research activities with project leaders and assist in planning future studies. Consult with USAID and Government officials regarding cooperation, administrative matters, and research studies.
1979/Apr 17-May 20	M. Fall	Review and discuss current research and training activities with project leaders, their counterparts, and USAID officials.
1979/Jun 24-July 10	J.W. DeGrazio	Confer with USAID and government officials regarding proposed Bangladesh Vertebrate Pest Project.
1979/Jun 6 - 31	S.A. Shumake	Review and discuss research activities and plan correlating studies to be done at DWRC; advise personnel on security measures for rats, safety measures for rats, safety measures for hazardous chemical; assess requirements for shipping rats from Bangladesh to DWRC.
1979/Sep 12-Oct 6	P.J. Savarie	Assist Project Leaders and counterparts in laboratory and field studies. Instruct personnel in use of vertebrate pest control agents, LD50 procedures

51

		and laboratory procedures.
1980/Feb 16-Mar 13	R.T. Sterner	Provide assistance in predator field research in Bangladesh.
1980/Mar 24-Apr 20	J.W. DeGrazio	Review status of research R.D. Thompson studies and assist in planning future activities.
1980/Aug 13-Sep 13	P.J. Savarie	Assist in planning and conducting rodent control studies. Consult on parallel studies being conducted in Denver and Los Baños, Philippines.
1981/Jan 22-Feb 14	L.A. Fiedler	Conduct ongoing studies in the field and at the laboratory (BARI). Consult with BARI officials. Plan and coordinate activities until arrival of new Project Leader.
1981/Mar 12 - 28	L.A. Fiedler	Complete field study "Evaluation of rat control in wheat" initiated November 1980. Consult with BARI and USAID officials re Project in absence of new Project Leader.
1981/Sep 14-Oct 4	J.W. DeGrazio	Review administrative and Program activities with Project Leader, USAID, and host Government officials.
1982/Nov 16-Dec 16	R.L. Bruggers	Assess bird pest situation and conduct bird pest studies.
1983/Mar 23-Apr 29	J.W. DeGrazio	Review research and administrative activities.

1983/Sep 7-Oct 7	P.J. Savarie	Assist with laboratory evaluation of new rodenticides; evaluate status of rodenticides used; and plan future toxicological tests.
1983/May 13-Jun 13	J.W. DeGrazio	Review Project and plan future research and activities.
1985/Jan 8 - 27	L.A. Fielder	Participate as vertebrate pest management specialist at Integrated Pest Management Training Workshop regarding vertebrate pests in sugarcane.
1985/Jan 8-Feb 28	M.W. Fall	Plan and present outline for jackal research and management program.
1985/Nov 19-Dec 22	M.M. Jaeger	Evaluate ongoing field research, meet with USAID and BARI officials on project status, and begin developing a work plan for 1986-1991, in absence of Project Leader.
1986/Mar 23-May 25	M.M. Jaeger	Prepare research plan for Vertebrate Pest Section in cooperation with USAID/Dhaka and personnel of the Bangladesh Agricultural Research Institute, while waiting for security clearances.
1986/Nov 18-Dec 20	R.L. Bruggers	Assist Project Leader in capturing and instrumenting jackals, surveying rice fields for rodent infestations, and surveying farmers' houses for post-harvest grain losses.

1987/Apr 11-May 1	D. L. Otis	Provide guidance and recommend sampling techniques and experimental design to be used in evaluating vertebrate pest control strategies.
1988/Mar 24-Apr 2	L. Raver	USDA/OICD Technical Assistance Division review of PASA financial arrangements relative to transferring remaining funds from USDI to USDA.
1988/Apr 6 - 20 1988/Apr 6 - 26	R.F. Reidinger R.L. Bruggers	Assist personnel reviewing Vertebrate Pest Management (VPM) research activities and formulating future project activities.
1988/Apr 13 - 19	J.E. Brooks	Participate in Bangladesh VPM Research review.
1989/Mar 29-Apr 8	R.L. Bruggers	Review ongoing VPM research activities and help develop rodent control implementation strategy and future technical assistance and training plans.

60

APPENDIX 2.0

2.1 VPS Research, Training, and Extension Activities

On-farm outreach peaked in 1984 in association with the second rodent control campaign, when half-day seminars in Bengali on vertebrate pest problems and control illustrated with color slide and narrative were given to 1,040 individuals at BARI regional (PARS) and subregional (SubRARS) Agricultural Research Stations, at the Thana Training and Development Centre (TTDC), and to students and training staff at Agricultural Extension Training Institutes (AETT) from September through December.

Locations and numbers of participants at half-day training seminars on vertebrate pest control in Bangladesh during 1984 rodent control campaign.

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, Moulavi Bazar, Sylhet	40
PARS, Dinajpur	225
AETI, Barisal	105
AETI, Hathazari	220
AETI, Sylhet	179
AETI, Dinajpur	112

2.2 VPS Pest Surveys and Damage Assessment Activities

Since its inception, the Project has attempted to "go to the farmers' fields" with all appropriate research under actual field conditions and in cooperation with farmers. This approach has resulted in project staff being in the field and visible to farmers for many months each year. As examples, the following pest surveys and damage assessments have been undertaken:

- Rodent damage to wheat, 1979
- Rodent ecology in sugarcane, 1981
- Lesser Bandicoot rats, damage to agriculture, 1981
- National assessment of rat damage to wheat, 1982

- Rat and jackal damage surveys in sugarcane, 1983 and 1984
- National rat control campaign surveys, 1983 and 1984
- Countrywide bird pest survey, 1985

Likewise, the following research activities have been conducted in association or cooperation with farmers:

- Controlling rodents in deepwater rice, 1979
- Field-testing from rodenticide in deepwater rice, 1979
- Comparing techniques for monitoring small mammal abundance, 1980
- Rodent movements in wheat fields, 1980
- Rodent control in wheat fields, 1980
- Rodent ecology trials of two rodenticides in village housing clusters, 1981
- Bird damage control in sprouting wheat, 1981
- Comparing field trials of two rodenticides in wheat fields, 1982
- Comparing two rodenticides on island villages surrounded by deepwater rice, 1982
- Evaluating damage assessment technique in deepwater rice, 1982
- Post-harvest stored food losses in villages and farms, 1982
- Operation OSKER (One Square Kilometer Eradication of Rats), 1983
- Simulated rat damage in deepwater rice, 1983
- Evaluating copper oxychloride as a bird repellent to increase wheat yield, 1984
- Simulated bird damage to sprouting wheat, 1984
- Trapping golden jackals, 1985
- Comparison trials of three rodenticides in wheat fields, 1985
- Wheat yield reduction through simulated bird damage at the sprouting stage, 1985

2.3 VPS Linkage to Bangladesh Extension Service

A variety of other efforts have been made to get the results of vertebrate pest research to users, including:

- eight radio broadcasts in Bengali on vertebrate pest problem agriculture by the VPS staff during 1984 and in subsequent years;

- a draft outline or a training manual on vertebrate pest research and management methods in Bangladesh, aimed at agricultural extension workers. Although this manual was never completed,

a similar manual that has some applicability to the Bangladesh situation has been prepared by the USAID-funded, DWRC/Pakistan Vertebrate Pest Project. A manual on "Rodent Pests, then Biology and Control in Bangladesh", was prepared by the Bangladesh-German Plant Protection Program with technical input from the VPC Project;

- informal discussions with staff of Bangladesh Agricultural University, Mymensingh, about adding a vertebrate pest management complement to their curricula;

- occasional lectures by VPCL Scientists at the Institute of Postgraduate Studies in Agriculture at Salna, Gazipur;

acceptability, they have all been initially evaluated under farm or village situations and determined to be preliminary, or at least, acceptable. Several techniques developed over the course of this project, include:

- ready-made ZnP bait cakes for rodent control in wheat;
- ready-made anticoagulant packets for rodent control at the village level;
- a technique to reduce rodent damage to deepwater rice;
- a seed dressing to reduce bird damage to sprouting wheat; and
- a reflective tape to reduce bird damage to ripening crops.

These research examples are described in more detail on the following pages.

First, the most cost-effective technique, and the technique most implemented and demonstrated as appropriate technology, was the ZnP bait cakes developed and used in the 1983 and 1984 rodent control in wheat campaigns. Research by the Project into the efficacy of inexpensive (two to three Taka) took into consideration the amount farmers would pay. Follow-up damage assessments suggested that this effort resulted in a 70 percent reduction in rat damage and a cost benefit ratio of 1:30. FAO monitored the socioeconomic impact of this effort and described it as a model for technical transfer in developing countries in a book entitled, "Motivating Farmers for Action" (Adhikarya and Posamentier 1987).

Second, methods were developed for large-scale demonstration evaluation for cost-effective reduction of rodent-caused stored food losses at farm and village level through use of anticoagulant baits in ready-made form.

During the monsoon season, rodents temporarily desert the flooded fields and concentrate in elevated areas. Bandicoot rats move close to, or actually into, human dwellings to join the resident household rodents, the roof rat and the house mouse (*Mus musculus*), insectivoires (*Soricidae*), and the musk shrew (*Suncus murinus*). Trials were conducted in housing clusters that compared zinc phosphide (two percent) and brodifacoum baits (0.005 percent), when applied at weekly intervals. At the VPC, 50-g zinc phosphide and brodifacoum baits were prepared and packaged in plastic bags. One packet was provided to each house

owner with advice that it be divided into five parts and each placed in a different location.

Brodifacoum gave consistently greater reduction in animal activity than zinc phosphide in each housing cluster. Based on the tracking tile data, the overall reduction was 97 percent for brodifacoum and 86 percent for zinc phosphide; reference houses showed a 39 percent increase in activity. The results suggest that a large-scale baiting program during the monsoon season should be able to reduce rodent populations to nondestructive levels by the onset of the dry-season cropping period.

Third, methods were developed for large-scale demonstration evaluations for cost-effective reduction of rodent damage to deepwater rice (Operation OSKER trial).

Operation OSKER (One Square Kilometer Eradication of Rats) was an attempt to eliminate rats from 1 km^2 of deepwater rice to demonstrate the logistical feasibility of such an effort and the practical application to reducing rat damage. Two deepwater rice areas, about 1 km^2 each, were selected in Tangail District. One area served as reference, and the other was treated with 0.005 percent brodifacoim rat bait cakes. The untreated area was characterized by winter crops of wheat, potato, melon, and monsoon. Rat activity was quantified before and after baiting. Baits were applied in fields, along roadways, and in and around houses on island/villages on four occasions: 16-18 August, 30 August-1 September, 11-13 September, and 23-24 October.

Activity in the treated area was reduced 85.5 percent by late September following the third poison application. The number of rodent burrow systems decreased 90.3 percent in the same period, compared to only 9.8 percent decrease in the untreated area. Nine hundred seventeen 50-g bait packets were used in the treated area during the four applications; 331 in island/villages, 350 in fields, and 236 on high ground and roads. The total cost for the operation was $126 (bait = $76, labor = $50) or $26/ha.

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

Fourth, bird-scaring reflecting tape was shown in Bangladesh and other Asian countries to protect ripening crops from parakeets.

Trials conducted between March 1984 and March 1985 evaluated the effectiveness of bird-scaring reflective tape to protect crops from birds in Bangladesh. When suspended in parallel rows above ripening crops, reflecting tape reduced damage by rose-ringed parakeet (*Psitticula kramei*), to sunflowers and corn; munias, (*Lonchura spp*), to foxtail millet (in the presence of alternate food); house crows (*Corvus splendens*), to sunflowers; jungle crows (*Corvus macrorhynchos*), to corn; and European tree sparrows (*Passer montanus*), to sorghum (all pest species). Ploceid weavers seemed to habituate rapidly to the tape when applied over a crop in a situation in which they were provided an unprotected entry point to the field. This tape is a synthetic resin film to which a silver layer is applied by vapor deposition, then coated with a colored resin. It offers an inexpensive, simple, safe method for protecting small fields of crops from birds, and is particularly appropriate for use under such conditions in developing countries.

Fifth, copper oxychloride was shown in preliminary trials to provide protection to sprouting wheat from birds.

Copper oxychloride, a locally available fungicide, proved in several trials with farmers and at research stations to be an effective repellent in treated plots to birds at 0.55 and 1.0 percent (by seed weight) when applied to wheat seed prior to sowing. Sprout counts and yield in treated plots ranged from 13.71 percent and 12-24 percent greater than in control plots. Although methiocarb, another fungicide is a more consistently effective bird repellent, copper oxychloride is the more attractive choice for Bangladesh because of its ready availability and minimal purchase cost.

Resources were provided, primarily through the GTZ/DAE project and FAO, to evaluate the agricultural, economic, and socioeconomic aspects of two national rodent control campaigns. DWRC feels that it would be very worthwhile to begin large-scale pilot demonstrations to evaluate the socioeconomic appropriateness of the other four technologies in any project extension. In the meantime, the logistical feasibility of such activities within the framework of BARC, BARI, USAID, and the Project will be tested with the September 1989 rodent control demonstration.

The Vertebrate Pest Project has one of the few women vertebrate pest research scientists in the world and certainly one of the most well-trained and productive ones in Asia. Dr. Sultana is an individual who is particularly dedicated to seeing vertebrate pest management techniques evaluated and implemented in Bangladesh, not an easy task, given the cultural and social constraints under which she works. Rural women are direct beneficiaries to developed and implemented vertebrate pest

programs, particularly those that implement rodent control at the farm level.

2.5 Project Scientists' Participation in National and International Study Tours, Workshops, or Conferences

1979: - Parvin Sultana attended a 2.5 month training program at the National Crop Protection Center, Los Baños, Philippines, in rodent ecology and control and designing a scheme for monitoring rat populations for an anticoagulant resistance.

- Parvin Sultana attended the 10th Vertebrate Pest Control Conference, Monterey, California, 23-25 Feb., 1982 and presented a paper, "Methods for Assessing Rat Damage to Growing Wheat in Bangladesh with Examples of Applications" at the 4th ASTM Symposium on Test Methods for Vertebrate Pest Control and Management Materials, Monterey, California, 26 February 1982.

1983: - M.A. Karim presented a paper, "Current Status of Vertebrate Pest Management in Field Crops in Bangladesh" at the National Symposium on Agricultural Research, BARC, Farmgate, Dhaka, 22-23 December 1983.

- M.Y. Mian, "Transferable Technology in Vertebrate Pest Management" presented at the training session on Transferable Technology at BARI, Joydevpur, 22 December 1983.

1984: - M.Y. Mian attended the 11th Vertebrate Pest Control Conference at Sacramento, California, 6-8 March, 1984. He worked with scientists at the DWRC, Denver, CO., 9-25 March and reviewed work on post-harvest losses of stored foods and the prevention of losses at Kansas State University, Manhattan, Kansas, 26-28 March 1984.

- M.E. Haque, "Laboratory Methods in Vertebrate Pest Research" presented at the Crop Production and Extension Resources Management Specialist Training Course, CERDI, Joydevpur, 19 April 1984.

- M.A. Karim, "Pest Birds of Bangladesh and Their Control"' presented at the Crop Production and Extension Resources Management Specialist Training Course, CERDI, Joydevpur, 19 April 1984.

- M.Y. Mian,"Rodents and Their Control in Bangladesh", presented at the Crop Production and Extension

Resources Management Specialist Training Course, CERDI, Joydevpur, 19 April 1984.

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

- Karim, A. Principal participant to the Integrated Pest Management Training Workshop, Consortium for International Crop Protection; Joydevpur, Bangladesh, 13-16 January 1985.

- Mian, Y. Principal participant at the Integrated Pest Management Training Workshop, Consortium for International Crop Protection; Joydevpur, Bangladesh, 13-16 January 1985.

1986: - Haque, M.E. "Major insect and vertebrate pests of wheat and their control". Presentation at the Crop Production Technology Training Course for Subject Matter Specialists; BARI, Joydevpur, Bangladesh, 2 March 1986.

- Mian, M.Y., P. Sultana, and M.E. Haque, 1986. "Vertebrate pests and their management in Bangladesh". Presentation at the Crop Production Technology Training Course for Subject Matter Specialists; BARI, Joydevpur, Bangladesh, 2 March 1986.

2.6 AID/Bangladesh-funded Publications

Ahmed, M. S. 1981. Evaluation of rat control techniques in experimental fields of the International Rice Research Institute. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 62 pp.

Ahmed, M. S., L. A. Fiedler, and E. A. Heinrichs. 1987. Economic losses by rats on experimental rice farms in the Philippines. Crop Prot. 6(4):271-276.

Ahmed, M. S., M. E. Haque, and J. E. Brooks. 1985. Alternate foods of bandicoot rats in deepwater rice areas of Bangladesh. Int. Rice Res. Newsl. 10(3):31.

Ahmed, M. S., M. Y. Mian, and J. E. Brooks. 1984. Patterns of bandicoot rat damage to deepwater rice in Bangladesh. IRRN 9:4, 21.

68

Ahmed, M. S., M. Y. Mian, M. E. Haque, and J. E. Brooks. 1986. Burrowing pattern of bandicoot rats in deepwater rice fields. Int. Rice Res. Newsl. 11(1):25.

Ahmed, M. S., M. Y. Mian, M. E. Haque, and J. E. Brooks. 1986. Estimating rat damage in deepwater rice. Bangladesh J. Sci. Res. 4(2):131-146.

Brooks, J. E., P. Sultana, and R. M. Poché. 1985. Damage by Bandicota bengalensis to growing wheat in Bangladesh and methods of control. Acta Zool. Fenn. 173:135-137.

Bruggers, R. L., P. Sultana, J. E. Brooks, l. A. Fiedler, m. Rimpel, S. Manikowski, N. Shivanarayan, N. Santhaiah, and I. Okuno. 1984. Preliminary investigations of the effectiveness of trimethacarb as a bird repellent in developing countries. Proc. 11th Vertebr. Pest Conf., Sacramento, California, 11:192-203.

Bullard, R. W., R. L. Bruggers, S. R. Kilburn, and L. A. Fiedler. 1983. Sensory-cue enhancement of the bird repellency of methiocarb. Crop Prot. 2(4):387-398.

Bullard, R. and H. Shuyler. 1983. Springing the trap on postharvest food loss. Horizons 2(7):26-32.

De Grazio, J. W. 1978. World Bird damage problems. Proc. 8th Vertebr. Pest Conf., Sacramento, California, 8:9-24.

Haque, M. E., S. Ahmad, R. K. Pandit, M. A. Karim, and J. E. Brooks. 1985. Assessment of sugarcane damage by jackal and rat in Sripur area of Bangladesh. Bangladesh J. Sugarcane 7:47-51.

Haque, M. E. and L. A. Fiedler. 1985. Yield reduction in wheat by simulated rat damage. Trop. Pest Manage. 31(4):296-298.

Karim, M. A., M. E. Haque, M. Y. Mian, and J. E. Brooks. 1985. Current status of vertebrate pest management in field crops in Bangladesh. Pages 182-183 in Ten years of Agricultural Research in Bangladesh. Proc. Natl. Symp. Agric. Res., BARC, Dhaka (Abstr.).

Mian, Y. 1982. Ecology and control of sympatric rodents on islands adjacent to deep-water rice in Bangladesh. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 111 pp.

Mian, M. Y., M. S. Ahmed, and J. E. Brooks. 1987. Small mammals and stored food losses in farm households in Bangladesh. Crop Prot. 6(3):200-203.

Poché, R. M. 1980. Range extension of Rattus exulans in South Asia. Mammalia 44(2):272.

Poché, R. M., S. J. Evans, P. Sultana, M. E. Haque, R. Sterner, and M. A. Siddique. 1987. Notes on the golden jackal (Canis aureus) in Bangladesh. Mammalia 51(2):259-270.

Poché, R. M., M. E. Haque, M. Y. Mian, P. Sultana, and M. A. Karim. 1981. Rice yield reduction by simulated rat damage in Bangladesh. Trop. Pest Manage. 27(2):242-246.

Poché, R. M., Md. A. Karim, and Md. E. Haque. 1980. Bird damage control in sprouting wheat. Bangladesh J. Agric. Res. 5(2):41-46.

Poché, R. M. and Md. Y. Mian. 1985. Comparison of two methods for monitoring population indices of small mammals on seasonal islands. Acta Theriologica 30(8):161-165.

Poché, R. M. and Md. Y. Mian. 1986. Effectiveness of four rodenticides in deepwater rice. Z. Angew. Zool. 73(1):37-48.

Poché, R. M., Md. Y. Mian, Md. E. Haque, and P. Sultana. 1982. Rodent damage and burrowing characteristics in Bangladesh wheat fields. J. Wildl. Manage. 46(1):139-147.

Poché, R. M., M. Y. Mian, R. Sterner, M. E. Haque, and P. Sultana. 1986. Rodent movements in wheat fields. Mammalia 50(2):165-172.

Poché, R. M., P. Sultana, S. R. Evans, M. E. Haque, M. A. Karim, and M. A. Sidduque. 1982. Nesokia indica from Bangladesh. Mammalia 46(4):547-549.

Poché, R. M. P. Sultana, Md. Y. Mian, and Md. E. Haque. 1979. Studies with zinc phosphide on Bandicota bengalensis (Gray) and Rattus rattus (Linnaeus) in Bangladesh. Bangladesh J. Zool. 7(2):117-123.

Sultana, P. 1981. Comparing food preference evaluation techniques for lesser bandicoot rats (Bandicota bengalensis Gray). Bangladesh J. Agric. Res. 6(2):51-57.

Sultana, P. 1985. Factors affecting the performance of bird control chemicals. Unpublished Ph.D. Thesis, Colorado State University, Fort Collins, Colorado. 134 pp.

Sultana, P. and J. E. Brooks. 1986. Laboratory and field evaluation of 4-aminopyridine (Avitrol^{R}) as a bird repellent in Bangladesh. Bangladesh J. Agric. 11(4):49-54.

Sultana, P., J. E. Brooks, and R. L. Bruggers. 1986. Repellency and toxicity of bird control chemicals to pest birds in Bangladesh. Trop. Pest Manage. 32(3):246-248.

Sultana, P., J. E Brooks, and R. M. Poché. 1983. Methods for assessing rat damage to growing wheat in Bangladesh with examples of applications. Vertebrate Pest Control and Management Materials, ASTM STP 817, D. E. Kaukeinen, ed., American Society for Testing and Materials, pp. 231-238.

Sultana, P. and R. M. Poché. 1982. Food intake in three Asian Muridae. Mammalia 46(3):402-405.

2.7 Other USAID-funded Publications

Ahmad, E., I. Hussain, and J. E. Brooks. 1987. Vertebrate pests of Pakistan. Pages 332-348 in Integrated Pest Management (C. Inayatullah, compiler). Pakistan Agricultural Research Council, Islamabad, Pakistan.

Alfonso, P. J. and J. P. Sumangil. 1970. Control of ricefield rats, Chapter 15. Pages 204-211 in Rice Production Manual. University of the Philippines, College of Agriculture.

Anonymous. 1976. Rodent control saves crops. War on Hunger 10(6):5-7.

Anonymous. 1976. Poisoned rice in Philippines proves success. Rice J. 79(5):6-7.

Benigno, E. A. 1972. Estimating population parameters of the ricefield rat (Rattus rattus mindanensis Mearns). Unpublished M.S. Thesis, University of the Philippines at Los Baños. 49 pp.

Benigno, E. A. 1979. The assessment of infield damage to crops caused by rats. Unpublished Ph.D. Thesis, University of the Philippines at Los Baños. 124 pp.

Benigno, E. A. 1980. Rat damage distribution in rice and corn fields. Philipp. Agric. 63(3):239-250.

Benigno, E. A. 1980. Assessing crop damage caused by small mammals. Pages 139-148 in F. F. Sanchez (ed.) Proc. Symp. on Small Mammals: Problems and Control. BIOTROP Spec. Publ. 12; Los Baños, Philippines; December 6-8, 1977.

Benigno, E. A. 1980. Methods of assessing small mammal pest population. Pages 149-156 in F. F. Sanchez (ed.) Proc. Symp. on Small Mammals: Problems and Control. BIOTROP Spec. Publ. 12; Los Baños, Philippines; December 6-8, 1977.

Benigno, E. A., J. A. Jackman, L. Fiedler, M. M. Hoque, and F. G. Palis. 1983. Ratpop: a population model of the ricefield rat (Rattus rattus mindanensis Mearns). Philipp. Agric. 66(4):379-396.

Benigno, E. A., R. F. Reidinger, J. L. Libay, and F. F. Sanchez. 1976. Sustained baiting with anticoagulant rodenticides in cornfields and assessment of rat damage. Proc. 7th Natl. Pest Control Counc. Conf. 7:146.

Brooks, J. E. 1987. Crop and stored food losses caused by vertebrate pests in Pakistan. The Econogram 3(2):3,4.

Brooks, J. E., E. Ahmad, and I. Hussain. 1988. Characteristics of damage by vertebrate pests to groundnuts in Pakistan. Proc. 13th Vertebr. Pest Conf., Monterey, California, 13:129-133.

Brooks, J. E., P. T. Htun, H. Naing, and D. W. Walton. 1981. Food requirements of the lesser bandicoot rat. Acta Theriol. 26,24:373-379.

Bruggers, R. L. 1980. Marking ploceid weavers with leg streamers. Ostrich 51(4):193-197.

Bruggers, R. L. and W. B. Jackson. 1981. Suggested methods for determining the efficacy of vertebrate control agents in developing countries. Vertebrate Pest Control and Management Materials, ASTM STP 752, E. W. Schafer, Jr., and C. R. Walker, eds., American Society for Testing and Materials, pp. 15-28.

Bullard, R. W. 1970. Variation of chemical concentration in surface-coated and tableted grain baits. J. Wildl. Manage. 34:925-929.

Bullard, R. W., ed. 1978. Flavor Chemistry of Animal Foods. ACS Symp. Ser. No. 67, American Chemical Society, Washington, D.C. 175 pp.

Bullard, R. W. and G. Holguin. 1975. Flavor components of unprocessed rice (Oryza sativa L.). 170th Natl. Meet. Am. Chem. Soc., Chicago, Ill. (Abstr.)

Bullard, R. W. and G. Holguin. 1977. Volatile components of unprocessed rice (Oryza sativa L.). J. Agric. Food Chem. 25(1):99-103.

Bullard, R. W., G. Holguin, and J. E. Peterson. 1975. Determination of chlorophacinone and diphenadione residues in biological materials. J. Agric. Food Chem. 23(1):72-74.

Bullard, R. W., J. E. Peterson, and G. Holguin. 1971. Determination of chlorophacinone in blood plasma by gas-liquid chromatography or UV spectrophotometry. 27th Annu. Southwest Reg. Meet. Am. Chem. Soc., San Antonio, Texas, 27:14. (Abstr.)

Bullard, R. W. and S. A. Shumake. 1977. Food base flavor additive improves bait acceptance by ricefield rats. J. Wildl. Manage. 41(2):290-297.

Cadieux, C. L. 1969. Bats, rats, birds and hunger. War on Hunger 3(8):9-11.

Castro, F. B. 1978. Management of limiting factors in sustained anticoagulant baiting of lowland ricefield rats. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 43 pp.

Caudill, C. J. and S. E. Gaddis. 1973. A safe and efficient handling device for wild rodents. Lab. Anim. Sci. 23(5):685-686.

Corner, G. W. and E. W. Pearson. 1972. A miniature 30-MHz collar transmitter for small animals. J. Wildl. Manage. 36:657-661.

De la Paz, A. M. 1979. Assessment of rat damage to corn. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 37 pp.

Dizon, R. C. 1978. Diffusion of a rat control innovation among Masagana 99 farmers in Laguna, Philippines. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 69 pp.

Elias, D. J. and B. E. Johns. 1981. Response of rats to chronic ingestion of diphacinone. Bull. Environ. Contam. Toxicol. 27:559-567.

Elias, D. J., P. J. Savarie, D. J. Hayes, and M. W. Fall. 1983. A simulated burrow system for laboratory evaluation of vertebrate control fumigants. Vertebrate Pest Control and Management Materials, ASTM STP 817, D. E. Kaukeinen, ed., American Society for Testing and Materials, pp. 226-230.

Estioko, B. R. 1978. Sugarcane yield losses due to rodents with reference to species distribution, infield stalk damage, varietal preference, and movement under Philippine conditions. Unpublished Ph.D. Thesis, University of the Philippines at Los Baños. 76 pp.

Estioko, B. R. 1980. Rat damage and control in Philippine sugar cropping. Pages 160-168 in F. F. Sanchez (ed.) Proc. Symp. on Small Mammals: Problems and Control. BIOTROP Spec. Publ. 12; Los Baños, Philippines; December 6-8, 1977.

Fall, M. W. 1977. Rodents in tropical rice. Tech. Bull. No. 36. College of Agriculture, University of the Philippines at Los Baños. 37 pp.

Fall, M. W. 1980. Vertebrate damage control in agriculture. Proc. UC/AID Workshop "Curso de Entrenamiento/Taller en Control Integrado de Plagas." Tapachula, Chiapas, Mexico.

Fall, M. W. 1980. Management strategies for rodent damage problems in agriculture. Pages 177-182 in F. F. Sanchez (ed.) Proc. Symp. on Small Mammals: Problems and Control. BIOTROP Spec. Publ. 12; Los Baños, Philippines; December 6-8, 1977.

Fall, M. W. 1982. Agricultural development and the ecology of rodent control. Pages 443-451 in Alternative Strategies for Desert Development and Management, Vol. 2. Proc. UNITAR Intern. Conf., Sacramento, California, 1977. Pergamon Press, New York.

Fall, M. W. 1983. The ecology of pests: rodents. BIOTROP Spec. Publ. 18:79-80. (Abstr.)

Fall, M. W., G. A. Hood, and J. W. De Grazio. 1972. A vertebrate pest management workshop program in East Asia. Rodent Research Center, College, Laguna, Philippines. 27 pp. (mimeo)

Fall, M. W. and F. F. Sanchez. 1975. The Rodent Research Center. PANS. 21(2):206-209.

Fall, M. W. and J. P. Sumangil. 1980. National rat control program in the Philippines. Pages 9-15 in F. F. Sanchez (ed.) Proc. Symp. on Small Mammals: Problems and Control. BIOTROP Spec. Publ. 12; Los Baños, Philippines; December 6-8, 1977.

Fall, M. W. and R. R. West. 1973. Vertebrate pests in Southeast Asia. Proc. Pest Control Counc. Philipp. 4:18.

Fall, M. W., R. R. West, and A. L. Kolz. 1973. Plastic fasteners for rapid attachment of radio transmitters to rats. Philipp. Agric. 56:263-266.

Ferrer, L. S. 1973. A laboratory study on juvenile growth of the common ricefield rat. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 48 pp.

Ferrer, L. S. 1975. Growth of Rattus rattus mindanensis. Philipp. Agric. 59(1&2):37-42.

Fiedler, L. A. 1987. Cost-efficacy of rodent control recommendations for several agricultural crops in the Philippines. Page 403 in C.G.J. Richards and T. Y. Ku, (eds.) Control of Mammal Pests. Taylor & Francis, London, 406 pp. (Abstr.)

Gaddis, S. E. and S. A. Shumake. 1982. A long-haul transport container with water provision for individually caged rats. Lab. Anim. Sci. 32(2):173-174.

Garrison, M. V., and C. P. Breidenstein. 1970. Digestion of sugarcane by the Polynesian rat. J. Wildl. Manage. 34:520-522.

Garrison, M. V. and B. E. Johns. 1975. Antifertility effects of SC-20775 in Norway and Polynesian rats. J. Wildl. Manage. 39(1):26-29.

Gras, G., C. Hasselman, C. Pellissier, and R. Bruggers. 1981. Residue analysis of methiocarb applied to ripening sorghum as a bird repellent in Senegal. Bull. Environ. Contam. Toxicol. 26:393-400.

Guerrero, R. D. III. 1970. The yield reduction of rice caused by mechanical and actual rat damage. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 47 pp.

Guerrero, R. D. III. 1971. The effect of simulated rat tiller cutting on the yield of rice. Philipp. Agric. 54:439-447.

Hoque, M. M. 1973. The toxicity of four anticoagulant rodenticides to Rattus rattus mindanensis Mearns. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 27 pp.

Hoque, M. M. 1979. Development of an anticoagulant resistance monitoring program for Philippine rats. Unpublished Ph.D. Thesis, University of the Philippines at Los Baños. 63 pp.

Hoque, M. 1980. Rat control in pineapple. Crop Protection Newsletter 2(3&4):14-15.

Hoque, M. M. 1983. Development of an anticoagulant resistance monitoring program for Philippine rats. Philipp. Agric. 66(1):36-46.

Hoque, M. M. 1983. Rat control in coconut-pineapple intercrop. Philipp. Agric. 66(1):82-89.

Hoque, M. M., E. A. Benigno, F. G. Palis, and J. L. Olvida. 1986. Evaluation of sampling techniques in assessing rat damage to corn. Philipp. Agric. 69(1):63-70.

Hoque, M. M., L. A. Fiedler, and E. A. Benigno. 1983. Control of rat damage to corn by sustained baiting. National Crop Protection Center Leaflet Series 6, 2 pp.

Hoque, M. M. and R. F. Reidinger. 1980. Relationships of costs to oral toxicities in five rodenticides available commercially in the Philippines. Pages 205-209 in F. F. Sanchez (ed.) Proc. Symp. on Small Mammals: Problems and Control. BIOTROP Spec. Publ. 12; Los Baños, Philippines; December 6-8, 1977.

Hussain, I., E. Ahmad, and J. E. Brooks. 1987. Control of vertebrate pests in Pakistan. Pages 349-370 in Integrated Pest Management (C. Inayatullah, compiler). Pakistan Agricultural Research Council, Islamabad, Pakistan.

Johns, B. E. and H. P. Pan. 1981. Analytical techniques for fluorescent chemicals used as systemic or external wildlife markers. Vertebrate Pest Control and Management Materials, ASTM STP 752, E. W. Schafer, Jr. and C. R. Walker, eds., American Society for Testing and Materials, pp. 86-93.

Johns, B. E. and R. D. Thompson. 1979. Acute toxicant identification in whole bodies and baits without chemical analysis. Avian and Mammalian Wildlife Toxicology, ASTM STP 693, E. E. Kenaga, ed., American Society for Testing and Materials, pp. 80-88.

Karim, M. A. 1983. Effects of zinc phosphide treatments on Hawaiian sugarcane rat populations. Unpublished Ph.D. Thesis, Bowling Green State University, Bowling Green, Ohio. 186 pp.

Kennelly, J. J., M. V. Garrison, and B. E. Johns. 1970. Laboratory studies of the effect of U-5897 on the reproduction of wild male rats. J. Wildl. Manage. 34:508-513.

76

Kennelly, J. J., B. E. Johns, and M. V. Garrison. 1972. Influence of sterile males on fecundity of a rat colony. J. Wildl. Manage. 36:161-165.

Kolz, A. L., G. W. Corner, and H. P. Tietjen. 1972. A radio-frequency beacon transmitter for small mammals. J. Wildl. Manage. 36:177-179.

Kolz, A. L. and R. E. Johnson. 1975. An elevating mechanism for mobile receiving antennas. J. Wildl. Manage. 39(4):819-820.

Kolz, A. L. and R. E. Johnson. 1976. Coulometric recorder for timing and counting events in the field. J. Wildl. Manage. 40(2):278-282.

LaVoie, G. K., G. C. Atwell, F. N. Swink, J. P. Sumangil, and J. L. Libay. 1971. Movement of the ricefield rat, Rattus rattus mindanensis, in response to flooding and plowing as shown by fluorescent bone labeling. Philipp. Agric. 54:325-330.

LaVoie, G. K., F. N. Swink, and J. P. Sumangil. 1971. Destruction of rice tillers by rats in relation to stages of rice development in Luzon. Philipp. Agric. 54:175-181.

Marges, B. E. 1972. Reproduction and seasonal abundance of the ricefield rat (Rattus rattus mindanensis Mearns) at Siniloan, Laguna. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 43 pp.

Marges, B. E., E. A. Benigno, and P. J. Alfonso. 1972. Studies on reproduction and movement of the ricefield rat (Rattus rattus mindanensis) at Siniloan, Laguna. Proc. Pest Control Counc. Philipp. 3:62-63.

Philippine Council for Agriculture and Resources Research and Development. 1985. The Philippines recommends for rodent control. PCARRD Tech. Bull. Series No. 57. 54 pp.

Reidinger, R. F., Jr., G. K. Beauchamp, and M. Barth. 1982. Conditioned aversion to a taste perceived while grooming. Physiol. Behav. 28:715-723.

Reidinger, R. F., Jr., J. L. Libay, and A. L. Kolz. 1985. Field trial of an electrical barrier for protecting rice fields from rat damage. Philipp. Agric. 68(2):169-179.

Samedy, J. P., G. C. Mitchell, R. M. Engeman, M. S. Bornstein, and N. P. Groninger. 1986. Preharvest corn losses to vertebrate pests in Haiti. An. Mus. Hist. Nat. Valparaíso 17:129-132.

Sanchez, D. C. 1972. Acceptance of some common foods by the ricefield rats (Rattus rattus mindanensis and Rattus argentiventer) and its relation to selection of bait carriers. Proc. Pest Control Counc. Philipp. 3:60.

Sanchez, D. C. 1977. Population patterns of sympatric rodents: Rattus r. mindanensis (Mearns) and R. argentiventer (Robinson and Kloss) associated with the rice crop in Oriental Mindoro, Philippines (1973). Unpublished M.S. Thesis, University of the Philippines at Los Baños.

Sanchez, F. F. 1975. Rodents affecting food supplies in developing countries: problems and needs. FAO Plant Prot. Bull. 23(3/4): 96-102.

Sanchez, F. F. and E. A. Benigno. 1981. Trends in rodent pest management. Symp. on Pest Ecology and Pest Management. BIOTROP; Bogor, Indonesia; December 3-4, 1981. 77 pp. (mimeo)

Sanchez, F. F. and R. F. Reidinger. 1980. Control of agricultural rodents through the sustained baiting method. Pages 183-186 in F. F. Sanchez (ed.) Proc. Symp. on Small Mammals: Problems and Control. BIOTROP Spec. Publ. 12; Los Baños, Philippines; December 6-8, 1977.

Savarie, P. J. 1980. Problems and recent advances in the development of rodenticides. Pages 187-204 in F. F. Sanchez (ed.) Proc. Symp. on Small Mammals: Problems and Control. BIOTROP Spec. Publ. 12; Los Baños, Philippines; December 6-8, 1977.

Savarie, P. J. and D. J. Hayes. 1980. Markers for toxic grease formulations. Rodent Newsletter 4(2):14.

Savarie, P. J., G. H. Matschke, E. W. Schafer, Jr., and G. J. Dasch. 1973. UK-786 possible species-specific toxicant for Norway rats. Nature 241(5391):551-552.

Savarie, P. J., J. R. Tigner, D. J. Elias, and D. J. Hayes. 1980. Development of a simple two-ingredient pyrotechnic fumigant. Proc. 9th Vertebr. Pest Conf., Fresno, California, 9:215-221.

Shafi, M. M., J. E. Brooks, and M. S. Khan Rana (eds.). 1987. Course Manual on Vertebrate Pest Management. National Agricultural Research Centre (NARC) Training Institute, Islamabad, Pakistan. 246 pp. (mimeo)

Shumake, S. A. 1977. The search for applications of chemical signals in wildlife management. Pages 357-376 in D. Muller-Schwarze, ed., Chemical Signals in Vertebrates. Plenum Publishing Corp., New York.

Shumake, S. A. 1978. Food preference behavior in birds and mammals. Pages 21-42 in R. W. Bullard, ed., Flavor Chemistry of Animal Foods. American Chemical Society, Washington, D.C.

Shumake, S. A. and K. A. Crane. 1980. Laboratory tests of the repellent activity of selected chemicals for protecting corn from damage by cotton rats (Sigmodon hispidus). Rodent Newsletter 4(2):12.

Shumake, S. A., A. L. Kolz, K. A. Crane, and R. E. Johnson. 1982. Variables affecting ultrasound repellency in Philippine rats. J. Wildl. Manage. 46(1):148-155.

Shumake, S. A., A. L. Kolz, R. F. Reidinger, and M. W. Fall. 1979. Evaluation of nonlethal electrical barriers for crop protection against rodent damage. Vertebrate Pest Control and Management Materials, ASTM STP 680, J. R. Beck, ed., American Society for Testing and Materials, pp. 29-38.

Shumake, S. A., R. T. Sterner, S. E. Gaddis, and K. A. Crane. 1982. Conditioned taste aversion in Philippine rice rats (R. r. mindanensis): comparisons among drugs, dosages, modes of administration, and sexes. Anim. Learn. Behav. 10(4):499-504.

Shumake, S. A., R. D. Thompson, and R. W. Bullard. 1973. An automated odor test for rats. Behav. Res. Methods Instrum. 5(3):279-282.

Shumake, S. A., R. D. Thompson, and C. J. Caudill. 1971. Taste preference behavior of laboratory versus wild Norway rats. J. Comp. Physiol. Psychol. 77:489-494.

Sterner, R. T. 1982. A microcomputer-based system for continuous measurement of rodent food intake. Behav. Res. Methods Instrum. 14(6):526-531.

Suliman, S. M. 1980. The feeding behavior of the Nile rat (Arvicanthis niloticus). Unpublished M.S. Thesis, Bowling Green State University, Bowling Green, Ohio. 111 pp.

Suliman, S. M., S. A. Shumake, and W. B. Jackson. 1984. Food preference in the Nile rat Arvicanthis niloticus. Trop. Pest Manage. 30(2):151-158.

Sumangil, J. P. 1971. Burrows and breeding of ricefield rats in Cotabato, Philippines. Unpublished M.S. Thesis, Colorado State University, Fort Collins, Colorado. 38 pp.

Sumangil, J. P. 1972. Burrows and breeding of ricefield rats in Cotabato, Philippines. Proc. Pest Control Counc. Philipp. 3:61.

Sumangil, J. P. 1972-1973. The effects of rain and shower in the feeding activity of Cotabato field rats. Philipp. Agric. 56(7&8):267-273.

Sumangil, J. P., P. J. Alfonso, and F. N. Swink. 1969. Rat control recommendations for rice. Page 26 in The Philippines Recommends for Rice-1969. University of the Philippines, College of Agriculture.

Sumangil, J. P., P. J. Alfonso, F. N. Swink, and J. Morales. 1970. More effective control of rats. Pages 32-33 in The Philippines Recommends for Rice-1970. Natl. Food Agric. Counc., Manila, Philippines.

Swink, F. N., G. K. LaVoie, G. C. Atwell, J. P. Sumangil, and A. M. dela Paz. 1973. Preliminary comparisons of three baiting methods for Philippine ricefield rats. Philipp. Agric. 56:251-257.

Thompson, R. D. and C. V. Grant. 1971. Automated preference testing apparatus for rating palatability of foods. J. Exp. Anal. Behav. 15:215-220.

Thompson, R. D., S. A. Shumake, and R. W. Bullard. 1972. Methodology for measuring taste and odor preference of rodents. Proc. 5th Vertebr. Pest Conf., Fresno, California, 5:36-42.

Tigner, J. R. 1972. Seasonal food habits of Rattus rattus mindanensis (the Philippine ricefield rat) in Central Luzon. U.S. Dep. Inter. Bur. Sport Fish. Wildl. 66 pp. (mimeo)

Tovar, I. 1982. Movements of Rattus rattus mindanensis (Mearns) in a rice cropland and freshwater marsh revealed by radio-tracking. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 81 pp.

Tuazon, E. D. 1979. The yield loss of rice at different stages of growth and intensities of damage. Unpublished M.S. Thesis, University of the Philippines at Los Baños. 24 pp.

West, R. R. and M. W. Fall. 1973. Some approaches for reducing rodent damage to growing rice. Pest Control Counc. Philipp. 4:18.

West, R. R., M. W. Fall, and E. A. Benigno. 1976. Comparison of tracking tiles and snap traps for obtaining population indices of Rattus rattus mindanensis in the Philippines. Philipp. Agric. 59(9,10):379-386.

West, R. R., M. W. Fall, and J. L. Libay. 1972. Field trial of multiple baiting with zinc phosphide to protect growing rice from damage by rats (Rattus rattus mindanensis). Proc. Crop. Sci. Soc. (Philipp.) 3:143-147.

West, R. R., M. W. Fall, and J. L. Libay. 1975. Reducing interactions among rats to improve bait acceptance. Philipp. Agric. 59(1&2):31-36.

West, R. R., M. W. Fall, and J. L. Libay. 1975. Tiller cutting behavior of rats in growing rice. Philipp. Agric. 59(1&2):27-30.

West, R. R., W. H. Robison, and A. M. dela Paz. 1973. Weatherability of zinc phosphide-treated rice baits. Philipp. Agric. 56:258-262.

West, R. R., D. C. Tolentino, and D. C. Sanchez. 1972. Evaluation of aerial dispersal of zinc phosphide baits for rodent damage control. Proc. Pest Control Counc. Philipp. 3:62.

2.8 Bangladesh Technical Reports

Technical Report No. 1. Rodent damage to wheat in Bangladesh. Vertebrate Pest Division, BARI, 1979.

Technical Report No. 2. Yield reduction in rice by simulated rat damage. Vertebrate Pest Division, BARI, October 1979.

Technical Report No. 3. Studies with zinc phosphide on *Bandicota bengalensis* and *Rattus rattus* in Bangladesh. Vertebrate Pest Division, BARI, January 1980.

Technical Report No. 4. Field trial using four rodenticides in deepwater rice. Vertebrate Pest Division, BARI, February 1980.

Technical Report No. 5. Bird damage control in Bangladesh sprouting wheat. Vertebrate Pest Division, BARI, April 1980.

Technical Report No. 6. Comparison of two methods for monitoring population indices of small mammals in Bangladesh deepwater rice. Vertebrate Pest Division, BARI, April 1980.

Technical Report No. 7. A comparison of three methods to determine food preferences in the lesser bandicoot rat (*Bandicota bengalensis* GRAY). Vertebrate Pest Division, BARI, June 1980.

Technical Report No. 8. Rodent movements in wheat fields. Vertebrate Pest Division, BARI, July 1980.

Technical Report No. 9. Yield reduction in wheat by simulated and actual rat damage. Vertebrate Pest Division, BARI, July 1980.

Technical Report No. 10. Rodent control in wheat fields. Vertebrate Pest Division, BARI, August 1980.

Technical Report No. 11. A preliminary report on rodent ecology in deepwater rice, Vertebrate Pest Division, November 1980.

Technical Report No. 12. Demonstration of rodent control in wheat in Gazaria Thana, Bangladesh. Vertebrate Pest Section, BARI, July 1981.

Technical Report No. 13. Comparative toxicity of several anticoagulant rodenticides to Bandicota bengalensis. Vertebrate Pest Section, BARI, December 1981.

Technical Report No. 14. Comparative trials of two rodenticides in small farm housing clusters. Vertebrate Pest Section, BARI, January 1982.

Technical Report No. 15. Control of pest bird damage to sprouting wheat. Vertebrate Pest Section, BARI, February 1982.

Technical Report No. 16. Rat damage to the 1982 wheat crop in Bangladesh. Vertebrate Pest Section, BARI, May 1982.

Technical Report No. 17. A comparative trial of two rodenticides in Bangladesh wheat fields. Vertebrate Pest Section, BARI, May 1982.

Technical Report No. 18. Laboratory and field evaluation of 4-aminopyridine (Avitrol) as a bird repellent in Bangladesh. Vertebrate Pest Section, BARI, May 1983.

Technical Report No. 19. Rodent control on island/villages in deepwater rice in Bangladesh. Vertebrate Pest Section, BARI, May 1983.

Technical Report No. 20. Preliminary laboratory evaluation of bromethalin as a rodenticide against Bandicota bengalensis. Vertebrate Pest Section, BARI, November 1983.

Technical Report No. 21. Rat damage characteristics and assessment methods in deepwater rice. Vertebrate Pest Section, BARI, December 1983.

Technical Report No. 22. Repellency and toxicity of bird control chemicals to Bangladesh pest birds. Vertebrate Pest Section, BARI, May 1983.

Technical Report No. 23. Simulated bird damage on sprouting what to estimate the yield loss. Vertebrate Pest Section, BARI, August 1983.

Technical Report No. 24. Jackal and rat damage assessment in sugarcane in the Sripur area, Bangladesh. Vertebrate Pest Section, BARI, November 1984.

Technical Report No. 25. Post-harvest stored food losses at farm and village level: small mammal species composition and population estimates. Vertebrate Pest Section, BARI, September 1984.

Technical Report No. 26. Effect of simulated rat damage on deepwater rice in Bangladesh. Vertebrate Pest Section, BARI, December 1984.

Technical Report No. 27. The agricultural and economic importance of the jackal (Canis aureus) in Bangladesh. Vertebrate Pest Section, BARI, December 1984.

Technical Report No. 28. Reflective ribbon as a bird repellent in maturing grain and oilseed crops in Bangladesh. Vertebrate Pest Section, BARI, March 1985.

Technical Report No. 29. A preliminary research bibliography for the jackal (Canis aureus) in Bangladesh. Vertebrate Pest Section, BARI, April 1985.

Technical Report No. 30. Wheat yield reduction by simulated bird damage at sprouting stage. Vertebrate Pest Section, BARI, April 1985.

Technical Report No. 31. Tiller cutting behavior of Bandicota bengalensis at different growth stages of wheat. Vertebrate Pest Section, BARI, June 1985.

Technical Report No. 32. Immobilization of golden jackals in Bangladesh with ketamine. Vertebrate Pest Section, BARI, July 1985.

Technical Report No. 33. Postharvest losses in farm houses in Bangladesh: rodent population estimates and potential food grain losses. Vertebrate Pest Section, BARI, July 1985.

AID 1020-20

APPENDIX 3.0

Project Design Summary
Logical Framework

Project Title & Number: Agricultural Research 388-0003: Vertebrate Pest Component

Life of Project
From FY 78 to FY 83
Total U.S. Funding $815,200
Date Prepared: August 1977

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: to develop vertebrate pest management methods, suited to the needs of small farmers, which are measurably reducing losses to vertebrate pests in farmers' fields in Bangladesh by 1985.	Measures of Goal Achievement: by 1985, reduced losses to vertebrate pests in major crops by 25% (extent of losses to vertebrate pests are currently unknown; a major purpose of this project will be to measure extent of losses in cereal and high cash value crops; the OVI for goal achievement may be modified as more information on nature and extent of losses is obtained as per end of project OVI, a below)	a. Inspection of published results of national damage surveys from 1981-1985. b. Inspection of statistical reports of the Agricultural Economics Section of the Ministry of Agriculture.	Assumptions for achieving goal targets: a. That there is adequate linkage between research activities of the project and extension programs in the area of plant protection. b. That extension activities in plant protection are strengthened by existing bilateral assistance programs and by the BDG. c. That suitable alternative control methods can be developed using the
Project Purpose: to establish an ongoing research capability (as a Vertebrate Pest Division of the Bangladesh Agricultural Research Institute which is adapting and developing vertebrate pest management techniques suited to the needs of small farmers.	Conditions that will indicate purpose has been achieved: End of project status. a. Accurate, sensitive damage assessment methodology developed for three major crops by 1981; traditional damage surveys for at least one major crop underway by 1981. b. Methods for assessing relative levels of rat activity suitable for scientific evaluation of effectiveness of control approaches in	a. Inspection of annual progress reports of the Vertebrate Pest Division of the BARI. b. Inspection of professional publications of scientists within the Division. c. Inspection of the BDG recurring budget.	Assumptions for achieving purpose: a. That there is adequate interest in vertebrate pest problems within the BARI to assure cooperative efforts and support in developing an ongoing research capability in the area of vertebrate pest management. b. That the research program, which is based on currently available information, does not require significant modification as more detailed information on the nature and extent of vertebrate pest
Outputs: a. Completion of physical facility, adequately equipped. b. Trained Bangladeshi scientists who are actively engaged in the design and evaluation of vertebrate pest management techniques, and who are actively conducting research in this area. c. Seminars held for the coordination of research activities in vertebrate pest management in Bangladesh.	Magnitude of Outputs: a. Facility completed (ca 3,000 sq. ft. with 4 offices, 1 secretarial/reception area, one general laboratory, 1 electronics room, 1 corridor/display area, 1 animal room 2 lavatories, and one storage area by 1979. Adequately equipped -- office, general maintenance, laboratory, electronic, field, and equipment for animal quarters by 1979.	a. Inspection of facility in 1979. b. Inspection of documents indicating completion of degrees by respective academic institutes; review of bonafide publications for national scientists for each year following graduation. c. Review of proceedings from seminars coordinating research activities; review of plans for or copublished results of cooperative research	Assumptions for achieving outputs: a. That required inputs are provided in a timely manner. b. That suitable candidates can be found for training programs who are interested, willing and capable of pursuing training in this specialized field. c. That other agricultural research institutes (e.g. BRRI, BSRI) in Bangladesh will have an interest in vertebrate pest management.
Inputs: a. Technical assistance b. Participant training c. Facility d. Commodities e. Seminars/workshops f. BDG operational expenses g. Organizational location of the vertebrate pest unit within the BARI.	Implementation Target (Type and Quantity) a. PASA contract with the Denver Wildlife Research Center for one long-term technician (3.5 yrs. in-country); short-term consultants (ca. 15 man-months); and, research support (ca. 6 man-months of professional researchists project year excluding FY 78; 23.1 pay periods/project year, except 6.5 for FY 78, technician; 6.5 pay period/project year for part-time secretary).	a. Inspection of annual progress reports of DWRC. b. Evaluation and degree of training certificates from participating training institutes. c. Inspection of physical facility in 1979 d. Inspection of physical facility in 1979 e. Inspection of proceedings of seminars and workshops. f. Inspection of the operational budget of the Vertebrate Pest Division of the BARI.	Assumptions for providing inputs: a. That USAID agrees to provide required inputs for the project component. b. That the BDG agrees to provide required inputs for the project component.

AID 1020-20 (11-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 78 to FY 82
Total U.S. Funding $835,200
Date Prepared: August 1977

Project Title & Number: Agricultural Research 388-0003: Vertebrate Pest Component

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes:	Measures of Goal Achievement:		Assumptions for achieving goal targets: c. research approaches of the Division.
Project Purpose:	Conditions that will indicate purpose has been achieved: End of project status. b. three major crops by 1981. c. Evaluation of the effectiveness of traditional control approaches vs. sustained baiting method completed by 1982. d. Detailed studies in problem areas initiated in 1981; ongoing by EOP e. Initial evaluations of alternative control methods underway by 1981, ongoing by EOP.		Assumptions for achieving purpose: b. problems is obtained.
Outputs: d. Coordinated research between the section and research institutes in other countries with expertise in this area. e. Research results leading to the development of simple, effective, economically beneficial, and safe vertebrate pest management methods.	Magnitude of Outputs. b. One trained at the conceptual Ph.D. level; two trained at the non-conceptual skilled M.S. level; average bona fide publications, post-graduate, 2 per year. c. 5 proceedings of coordinated research activities, or evidence of plans for cooperative research among agricultural research institutes in Bangladesh.	between the vertebrate Pest Division of BARI and other research institutes in Bangladesh. d. Review of plans for or copublished results of cooperative research between the Vertebrate Pest Division of BARI and institutes in other countries with expertise in vertebrate pest management.	Assumptions for achieving outputs: d. That BARI continues with its policy strong, effective leadership.
Inputs:	Implementation Target (Type and Quantity) b. One Ph.D. (academic training and 6 mos. non-academic training) from Bowling Green State University by 1981; two M.S. (academic training and 12 mos. non-academic training from University of the Philippines of Los Banos) by 1982; about 4 months non-academic training at the University of the Philippines at Los Banos (Rodent Research Center) by 1981.		Assumptions for providing inputs:

PROJECT [redacted] SUMMARY
LOGIC[redacted]AMEWORK

[redacted]
From FY [redacted]
Total U.S. Funding [redacted]
Date Prepared: [redacted]

Project Title & Number: Agricultural Research 388-0003: Vertebrate Pest Component

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes:	Measures of Goal Achievement:		Assumptions for achieving goal targets:
Project Purpose:	Conditions that will indicate purpose has been achieved: End of project status. f. Initial development of national monitoring program by 1982; ongoing by EOP. g. Standardization requirements for alternative rodenticides met by 1980. h. Research initiated on vertebrate pests in storage by 1982; ongoing by EOP.		Assumptions for achieving purpose:
Outputs:	Magnitude of Outputs: d. At least two cooperative research project per year between the Vertebrate Pest Division of BARI and institutes in other countries (e.g. IWPC, RRC) with expertise in vertebrate pest management.		Assumptions for achieving outputs:
Inputs:	Implementation Target (Type and Quantity) c. Facility completed as described in MOO a above. d. Equipment provided as described in Annex D. e. USAID support for materials required and transportation and per-diem of attendees until 1980; USAID support for materials required and BDG support for transportation and per diem until EOP; BDG support thereafter; 5 research seminars and two training conferences by EOP.		Assumptions for providing inputs:

AID 1020-20 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Project Title & Number: Agricultural Research 388-0003: Vertebrate Pest Component

Life of Project:
From FY 78 to FY 82
Total U.S. Funding $815,200
Date Prepared: August, 1977

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes:	Measures of Goal Achievement:		Assumptions for achieving goal targets:
Project Purpose:	Conditions that will indicate purpose has been achieved: End of project status. i. Needs of small farmer used as criteria for determine research priorities by 1980; ongoing by EOP j. That the BDG establishes a recurrent budget for the Vertebrate Pest Division of the BARI.		Assumptions for achieving purpose:
Outputs:	Magnitude of Outputs:		Assumptions for achieving outputs:
Inputs:	Implementation Target (Type and Quantity) f. Minimal personnel required: 4 senior scientific officers, 2 field technicians, 1 laboratory technician, 1 secretary, 1 driver, and 3 peons (estimated cost for five years of project = US $ 64,000) Maintenance and operational expenses, estimated at US $36,000 for five years of project. g. As a Division of the BARI.		Assumptions for providing inputs:

APPENDIX 4.0

Terms of Reference

Terms of Reference of the National Committee on Vertebrate Pest Research (VPR)*:

1. The committee will meet at least once quarterly to:

   i) review the annual VPR plan and make recommendations for further studies needed to support both farmers' acceptance and use of VPS-recommended technology.

   ii) coordinate the presentation of an annual plan of socioeconomic research drafted by FSR economists, DAE communication specialists, and representatives from VPS. (The plan should assign specific areas of socioeconomic investigation that support ongoing vertebrate field research.)

   iii) coordinate the secondment of both FSR and DAE personnel at the regional and national level for the extended field-testing planned by the VPS.

   iv) review the results of DAE plant protection activities to provide quality control of rodenticides, especially the distribution of zinc phosphide, production of baits, and prevention of adulteration.

   v) review vertebrate pest management practices relative to environmental impact, including effects on biodiversity and nontarget populations.

   vi) coordinate VPR activities of different institutions in Bangladesh.

   vii) sponsor workshops for participants in vertebrate pest management activities.

   viii) arrange for sponsorship and participation in regional (e.g., India, Pakistan, Burma, Sri Lanka) technical meetings on vertebrate pest management.

2. The committee may coopt any other member as and when necessary.

---

* Revision of original Terms of Reference drafted by evaluation team in consultation with M. M. Rahman and evaluation team.

APPENDIX 5.0

VERTEBRATE PEST MANAGEMENT RESEARCH COMPONENT UNDER
AGRICULTURAL RESEARCH II PROJECT (388-0051)
1989 EXTERNAL EVALUATION
STATEMENT OF WORK

I. PURPOSE:

Assess the overall impact and performance of the Vertebrate Pest Management Research component under ARP I and II.

II. BACKGROUND:

a) Agricultural Research I

AID's first major effort to assist the BDG in the field of agricultural research took the form of a $4,000,000 loan and $2,561,000 grant which were authorized in FY 1976. Additional grant funds for $830,800 (for a vertebrate pest component) and $1,000,000 were authorized in FY 1978 and FY 1980. Therefore, the total amount of grant funds in Phase I was $4,391,800. The background of this phase of the project is fully described in the Project Paper, Bangladesh--Agricultural Research (No. 388-0003).

This activity recognized the inadequacy of Bangladesh's resource base in terms of its rapidly expanding population and the resulting need to intensify agricultural production, particularly by means of diversifying crops and

developing new and improved varieties. Consequently, agricultural research was viewed as a key subsector of agriculture.

At the same time, both AID and the BDG recognized the need to support and strengthen the national agricultural research system, a responsibility that had been assigned to the Bangladesh Agricultural Research Council (BARC). This organization came into being under a BDG Ordinance in 1973. Therefore, the second emphasis of the first phase effort was designed to strengthen the BARC as the research coordinating body within Bangladesh and serving as the institution responsible for linking Bangladesh's agricultural research program with that of international research efforts.

With respect to Bangladesh Agricultural Research Institute (BARI), AID funds were intended to help the BDG to complete the basic physical facilities on the main research station at Joydebpur and the regional station at Ishurdi to enable adaptive and applied research to begin at these sites and to initiate a staff development program using both Bangladeshi staff and selected scientists from abroad. To this end, the AID credit was to finance the necessary laboratory equipment, farm development, the farm building complex, residential units and site development at

Joydebpur. An additional $1,000,000 in grant funds was provided for in FY 1980 for the development of the Ishurdi Regional Station.

As stated, the vertebrate pest component was added to the first ARP Project in FY 1978, increasing the original AID Grant by $830,800. The purpose of this addition to the research activities was to establish a Vertebrate Pest Section within BARI with a full staff of well-trained scientists to disseminate simple, effective, economically beneficial, and safe vertebrate pest management methods to farmers. Emphasis was placed on developing methods which would measurably reduce crop losses caused by vertebrate pests - mainly rats - in farmers' fields. A Vertebrate Pest Control Laboratory building was completed at the BARI central station at Joydebpur and was fully operational by September 1979.

AID engaged a PASA (Participating Agency Service Agreement) in December 1978 with the Denver Wildlife Research Center (DWRC) to provide the technical assistance to this component of the project. One long-term consultant was assigned to the project from December 1978. He assisted in developing vertebrate pest management methods suited to the needs of small farmers under Bangladesh conditions. In addition to the full-time consultant, DWRC is provided 15

person-months of short-term consultants with technical expertise in research planning, biometrics, pharmacology, toxicology of rodenticides, vertebrate behavior and physiology, chemical residue analysis and electronics (biotelemetry), and remote sensing during the life of this first research project.

b) Agricultural Research II

Due to the significant work done in the initial research effort, the USAID and Government of Bangladesh agreed that a much large activity was justifiable in enhancing agricultural research within the country.

Therefore, the Agricultural Research Project - Phase II (ARP-II) was initiated in July 1981 as a continuation of ARP-I. While ARP-I focused on building facilities, infrastructure, core staff, and developing multi-disciplinary priority research, ARP-II was designed to use those facilities and personnel to achieve the following goals:

- build capabilities to move agricultural research activities into farmers' fields.

- develop a farming systems research (FSR) approach with core disciplines.

- develop linkages among the agricultural research institutes to build a strong and relevant agricultural research system.

Under ARP-II, the Vertebrate Pest Management component continues to maintain long-term biologists stationed in Bangladesh to provide technical expertise and support to vertebrate pest management counterparts in identifying vertebrate pest problems, evaluating control techniques, and developing an overall strategy to manage vertebrate pests.

The current PASA extension allows for completing ongoing research, implementing results, developing a strategy for evaluating additional vertebrate problems, and institutionalizing vertebrate pest management in Bangladesh.

Initial funding in June 1981 for ARP-II allocated $17.5 million to the project which included a Vertebrate Pest Management PASA for $700,000. In June 1982 an additional $25.5 was added to the project which included two new activities of Water Management ($5 million) and Rice Research under BRRI/IRRI ($ 3 million). In June 1986, $805,000 was added for the Pest Management PASA to

the overall project and again in August 1987 another $1.3 million was added in the PASA. Thus, under the overall ARP-II project, $46.5 million has been made available of which $2.8 million has been specifically funded to the PASA with DWRC.

The total funding by USAID for over 10 years of work in the vertebrate pest management activity is:

ARP-I	$ 830,800
ARP-II	2,805,000
TOTAL	$3,635,800

Historically, this component has generally been well supported from both USAID and by BARC and has had a relatively open mandate to pursue its research agenda. Yet, a number of concerns have been expressed over the course of the project that have centered on the research itself, the long term institutional effects of the project, the outreach factor, and its relationship to the overall goals of the USAID project (ARP-II). All this suggests that a evaluation is both timely and essential. Three years still remain in the current PASA with the Denver Wildlife Research Center (DWRC) which leaves significant time to replace, if necessary, present project resources. It also sets the stage for planning for any new follow-on activities that may be required.

This is the first major external evaluation of this project component.

III. TERMS OF REFERENCE:

The evaluation team will thoroughly examine the following elements and/or issues for the vertebrate pest management component assessment:

1) The research performance vis-a-vis Bangladesh needs. Assess management effectiveness, timeliness, quantity, quality, relevance, and responsiveness to national research development objectives.

2) The outreach effects of the research to the Bangladeshi user. Provide quantification of the research efforts in terms of publications, farmer field days, on-farm research, outreach personnel and feedback to project management - including BARC and the DWRC.

3) The socio-economic dimension of the research and its impact to rural economic and cultural realities. Assess the resource allocations by project management to address these issues. Assess impact of participation by women - both as project implementers and as beneficiaries to the technology.

4) The interface of this component to the overall ARP-II project-particularly as related to the large investments made in Farming Systems Research (FSR). Determine the vertebrate pest management performance in relation to FSR and its role in terms of research compatibility and long term institutional linkages. Also, review the vertebrate pest component's relationship to the overall pest management program under BARI which was also financially supported under ARP-II. Include aspects such as the training program, research funding, institutional integration, and TA coordination between prime project contractor and DWRC.

5) The impact of this activity to long-term institutional sustainability and stability. Examine the research depth, management and operational skills; internal financial support mechanisms; professional, para-professional and support personnel performance levels; and training interventions. Review this is consonance with the various work plans developed for this activity.

6) The role, quality, effectiveness, flexibility, and appropriateness of technical support and backstopping of the Denver Wildlife Research Center (DWRC) to the project. Examine this in terms of a support response that is tailored to host country needs and the influence Bangladesh leadership had in determining backstopping needs by the Denver facility.

7) The replanning recommendations complete with realistic substantive proposals that will contribute to the PASA's success during the remaining period of this project.

8) The evaluation teams' perception of what any new follow-on activity after 1991 might be - if one is believed appropriate. A 3 page summary is all that is required. If no follow-on is proposed - cite changes needed to effectively phase out this activity over the life of project.

IV. STATEMENT OF WORK

A. General Responsibilities

The Contractor shall provide three specialists to perform the evaluation of the Vertebrate Pest Management component in ARP-I and ARP-II. Over $5.6 million has been funded to support this activity through a PASA with Denver Wildlife Research Center (DWRC) to provide technical assistance, commodities and training.

Overall coordination (Team Leader) of the evaluation will be provided by an agricultural development specialist who has had significant experience in developing and implementing agricultural institution building programs and

91

systems for research. He (she) will be a U.S. national and will be supported by a socio-economist (U.S.) and a research academic (Bangladesh).

B. Terms of the Contract

The Contractor shall provide the services of the 3 consultants to perform their evaluation in Bangladesh for 24 work days beginning c/a 1 March 1989. The Team Leader will have an additional 4 work days whereby a review of the home office program can be undertaken at the Denver Wildlife Research Center at Denver, Colorado immediately prior to his/her departure for Bangladesh.

The main work site location will be at the Bangladesh Agricultural Research Institute (BARI) at Joydebpur where the facilities of the vertebrate pest management project are located. However, evaluation team members will visit selected field research sites in the country as well as the offices of BARC and the prime ARP-II contractor in Dhaka. Due to the nearness of the Joydebpur facility, the evaluation teams members will maintain accommodations in Dhaka.

C. Composition of Contractor Team and Respective Scope of Work

1. Agriculture Development Specialist (Research Management)

He/she will be serve as the leader of the evaluation team and will be responsible for assembling all required information for the report.

Specific tasks include:

1. At Denver

a) Interview support specialists and administrative support personnel to get first hand knowledge of their inputs to the Mission supported activities over the past 10 year.

b) Review the participant training support procedures and relationships with U.S. institutions.

c) Examine the printing, reproduction, and other related services used by DWRC to support the activity under project funds.

d) Review the commodity procurement arrangements and analytical services for research handled by DWRC staff as provided for under the PASA.

c) Assess the research commitment and perceptions about the project by DWRC in terms of socio-economic research needs, long-term institution building strategy needs in Bangladesh, and the research interface to meet goals of the overall ARP-II project.

2. <u>In Bangladesh</u>

a) Assess the overall research quality of the vertebrate pest management component and its relevance to Bangladesh needs and consistences to the project's component goals, objectives and approved work plans.

b) Review this component in relation to the overall farming systems activity under ARP-II and to the overall Integrated Pest Management Program at BARI.

c) Address the issue of how much influence or direction the Bangladesh leadership gives to this project in terms of DWRC support from Denver, year to year planning, financial support thru BARI, and integration into the overall integrated pest management programs within BARI.

d) Determine the level of managerial capacities and capabilities within BARC, BARI and the vertebrate pest component itself to insure institutional sustainability of this component. Examine the para-professional support resources of the activity.

e) Examine the 1986-1991 Vertebrate Work Plan with particular emphasis on the control strategy and implementing results sections.

f) Based on the trip to Denver and experiences in Bangladesh, critically assess the impact of the DWRC support services. Include substantive independent interviews with BARC and BARI personnel, but more importantly - with the Bangladeshi staff and assigned DWRC biologist for this activity.

g) Prepare the summary and recommendations sections of the overall evaluation. Include any comments or thoughts on replanning needs in the project utilizing the present package of resources.

h) Provide thoughts (NTE 3 pages) of a post 1991 intervention if one is needed for vertebrate pest management.

i) Prepare a Project Evaluation Summary (PES).

Qualifications

Minimum M.S. level and preferably Ph.D. Team leader should be an individual who has the experience and understanding of implementing broad based agricultural research programs in developing countries. Candidates must understand institutional requirements in research - including the financial and human resource needs, the extension interface, research management/communications requirements and the "how to" approach in allocating scarce external and internal resources to research endeavors. Minimum five years work experience in overseas programs.

Good writing and synthesizing skills necessary in this task.

Work days required (24 in Bangladesh and 4 in U.S.)

Agricultural Socio-Economist

He/she will be primarily responsible for assessing the quality of the on-farm research, the socio-economic implications of the vertebrate pest research and research-outreach linkages.

a) Examine the improved technology produced in relationship to the economics of the user.

b) Review the research design and ensure technology(ies) are in relationship to the cultural realities and determine the competency of the planning mechanism.

c) Review the system of transmitting research fundings to field stations, other government agencies and to users that conveys pertinent information on economic and sociological impact.

d) Examine the research relevance of vertebrate pest management and the on-going on-farm research in the ARP-II project related to food crops and farming systems.

e) Review the role of women in the research process and propose areas of increased participation related to vertebrate pest management.

Qualifications

Minimum M.S. level and preferably Ph.D. This position requires an individual who has fundamental skills in socio-economic analysis, methodology and evaluation. He/she must be able to

assess the research design and/or approach in respect to the potential socio-economic relevance of research to agriculture. Previous experiences in research project evaluations is very helpful.

Work days required - 24 in Bangladesh.

Research Planning

He/she will be responsible for assessing the research technology, addressing the key issues of problem identification, control techniques, strategy and implementing results.

a) Review post and existing work plans of the vertebrate pest management component and assess relationship and adherence to stated goals and objectives.

b) Review program in context of the recently completed long range research strategy of Bangladesh.

c) Assess quality and relevance of the project's technical reports and findings.

d) Evaluate capacity of the Bangladesh staff trained under the project in terms of research design and implementation, management responsibilities and decision making processes, planning skills and in establishing and maintaining collegial relationships.

e) Assess the internal financial arrangements and quality of support by BARI and the relationships with BARC.

f) Provide inputs to future initiatives in the activity.

Qualifications

This position is reserved for a Bangladeshi professional, preferably with a biological background who is knowledgeable of the research system in the country and has had considerable experience in the administrative and/or academic environment related to agriculture. The person should have in depth appreciation of the research process and understand the operational modes of agricultural institutions in Bangladesh engaged in research, outreach and/or education.

Work days required - 24 in Bangladesh.

V. REPORTS

During first two days in country, the evaluation team will consolidate their work plan address evaluation issues with concerned BDG and AID officials.

While the AID manager and the designated BARC/BARI officials will be accessible to the evaluation team, the primary contact point for the team will be the Chief Scientific Officer and Head of the Vertebrate Pest Management unit at Joydebpur in coordination with the assigned in-country DWRC biologist.

The team will make a presentation to the Mission and BARC 4-5 days prior to departure and a final draft will be provided to the Mission prior to the departure of the evaluation team leader. This evaluation will contain a succint (up to three pages) summary outlining key observations and recommendations.

The contractor will provide 30 copies of subject evaluation in final form within 30 days after the team's departure to the USAID Project Manager in Dhaka.

APPENDIX 6.0

RESEARCH PROPOSAL AND GRANT REQUEST

FOR

PL-480 TITLE III FUNDING

Title: Developing a Strategy for Extending Rodent Control Technology to the Bangladeshi Farmer

Implementing Agency: Vertebrate Pest Section/BARI

Principal Investigator: Dr. Parvin Sultana, SSO/BARI

USAID/DWRC Advisor: Dr. M.M. Jaeger

Cooperating Agencies: BARC, DAE, FSR/BARI, Checchi

Dates: September - December, 1989

Overall Objective: To determine how best to implement the VPS/BARI research findings on methods and strategy of rodent control in Bangladesh.

Introduction

The Vertebrate Pest Section/BARI, with the assistance of the USAID/DWRC project "Vertebrate Pest Management Component of ARP-II", has recently completed field research on developing a strategy for the most cost-effective control of preharvest rat damage in rice and wheat in Bangladesh (Sultana and Jaeger, 1989). Conclusions are the following:

1. Long-term population reduction of rats is impractical and, therefore, annual control is necessary.
2. Annual control can be most cost-effective if focused on reducing rat damage in aman rice in September and October before flowering occurs and when the population of the principal pest species, the Lesser Bandicoot Rat (*Bandicota bengalensis*) is increasing to its annual high which occurs in late November and December coincident with the maturation and harvest of aman rice. Thorough control in September and

October can also substantially reduce rat damage to the subsequent wheat (March) and boro rice (May) crops, and will likely substantially reduce post-harvest loss of aman paddy.

3. Control should be directed at the burrow systems of B. bengalensis by inserting either a single zinc phosphide bait cake or a single tablet of the fumigant, aluminum phosphide, into the most recent burrow opening, and with the fumigant treatment, then sealing all the openings. Burrow systems are easy to distinguish and are concentrated near vegetation providing cover and food. Trapping B. bengalensis has so far proven to be an ineffective means of control.
4. Control should be undertaken cooperatively by all the farmers in an area since the chance of rat invasion from neighboring fields is high.

The final stage in the research process is to determine if these recommendations will be effectively adopted by the Bangladeshi farmer. Workable solutions must be developed for each of the following questions:

1. Collectively, can the farmers in an area use this technology effectively and safely?
2. Can the extension service effectively train farmers in rodent control and motivate them to practice it?
3. Can rodent control products which are effective and gain the farmers' confidence be made available on local markets?

This proposal describes the research to be directed at the first question.

Background and Justification

Preharvest rat damage to rice and wheat is the principal vertebrate pest problem in Bangladesh. Annual losses range from an estimated 150,000 to 450,000 mT. Postharvest rodent damage adds roughly 50,000 to 75,000 mT. The Government of Bangladesh initiated two projects in 1978 to deal with rodent

damage: (1) USAID/DWRC assistance to BARI to develop a reasearch capability, and (2) GTZ assistance to the Department of Agricultural Extension (DAE) to develop extension capabilities. The GTZ project terminated in 1984.

The early emphasis on research at BARI involved determining the principal rodent pest species and on formulating an effective toxic bait acceptable to the Bangladeshi farmer. A 1 g cake of wheat or rice containing 2% zinc phosphide was found to kill the average B. bengalensis (Poché et al., 1979) and to be readily purchased by farmers, with a production cost of about 0.05 taka per bait. Rat damage was wrongly assumed to be greatest in wheat and broadcast (deepwater) aman rice, and relatively insignificant in transplanted aman, boro and aus rice.

Based on this understanding of the problem the DAE/GTZ in cooperation with the FAO and VPS/BARI/USAID undertook national rat control campaigns in 1983 and 1984 from mid-January to mid-February directed at reducing damage in wheat. The objective of these campaigns was to instruct and to motivate farmers to carry out rodent control. During this process a multi-media campaign was developed, extension agents trained, and zinc phosphide cakes marketed. These campaigns are described as having been very successful (Adhikarya and Posamentier, 1987). After a one-year hiatus, the DAE followed up this initiative with annual campaigns from 1986 to the present in both the aman and wheat seasons. Prizes and a bounty for rat tails were offered as added incentive.

The impact of these campaigns on either reducing losses or generating interest among farmers in rat control is questionable. There have been no statistically meaningful surveys to evaluate either point. While a greater awareness of the problem may have been achieved, few farmers now seem to practice rodent control. A major reason seems to be a general lack of success among farmers in their attempts at control. This can be attributed to the following:

1. Lack of an effective means of control,
2. Lack of a clearly defined control strategy, and

3. Lack of a mechanism for cooperative control among neighbors.

The failure of zinc phosphide has been in the unavailability of properly formulated baits. Manufacturers quickly lost interest in producing the formulated bait cake and began instead distributing packets of zinc phosphide powder (80% a. i.) for formulation of baits by the farmer. Neither the farmer nor the extension agent understands the need for proper formulation or how to go about it. Consequently, the zinc phosphide is presented to rodents in baits with unpalatably high concentrations, or conversely with insufficient dosage. The problem is compounded by the rapid degradation of zinc phosphide in the high humidity common to Bangladesh. Distributors seem generally unconcerned about quality control, and in some cases appear to have diluted the product with charcoal powder which resembles the zinc phosphide. Recent analysis by DWRC chemists of over 20 brands found concentrations of zinc phosphide ranging from 3% to 96%.

What is required is a ready-to-use product that has been formulated by a responsible manufacturer and checked for quality before distribution to the farmer. One such product is currently available, the fumigant Phostoxin (aluminum phosphide) which is registered for use against insects in stored grain. Fumigating the burrow systems of B. bengalensis with aluminum phosphide tablets can be a cost-effective means of rat control (Sultana, unpubl.). The anticoagulant rodenticide brodificoum in the form of wax pellets is currently in the process of registration in Bangladesh. This is reported to be effective against B. bengalensis (Sultana et al., 1981; Poché and Mian, 1986).

A second problem with the campaigns is they seem to lack focus. Objectives were not clearly defined in terms of the most important crop to protect, rat species to target, control method to use, and the most effective time and place to carry out control. It was generally assumed that greater awareness among farmers of the need for rodent control together with the availability of a variety of control methods, including traditional means, would eventually

lower the overall numbers of rodents. Evidence suggests, however, that long-term population reduction of rodents is impractical and that an annual control program is necessary. For this to be cost-effective it must be selective, that is focused on when and where it can provide the greatest damage reduction. Field work during 1987 and 1988 by the VPS/BARI determined that population levels of B. bengalensis show a regular annual pattern of fluctuation peaking at the time of the aman harvest, and that annual control can be most cost-effective if done in September - October as rat numbers are increasing and before the flowering stage of the aman rice (Sultana and Jaeger, 1989). This research showed that rat damage could be substantial in transplanted-aman as well as broadcast-aman. The main points of this control strategy are outlined in the introduction, above.

Thirdly, for the farmer to be successful in rat control and remain motivated, he needs the cooperation of his neighbors. In general field sizes are very small and crop development is not synchronous among fields. Rats readily relocate to fields with the best combination of cover and ripening panicles. Farmers with later maturing fields must first achieve control in neighboring fields or risk re-invasion or late invasion in their own fields. Similarly, if only one resident in a village poisons rats in his house, it is likely the dead rats will be replaced by rats from the houses of his neighbors. The solution is timely and cooperative control.

Specific Objectives

This study is designed to determine the following:

1. Can farmers cost-effectively reduce preharvest rat damage in aman rice when using a properly formulated product and when carefully instructed about the control recommendations listed in the introduction?
2. Which method is more cost-effective, fumigation of burrows with Phostoxin or baiting burrows with zinc phosphide cakes?

3. Which focus of instruction and distribution of control materials is more effective, to individual farmers or to one local farmer representative who will do control for a group?
4. What are the major constraints influencing the practice of rat control by farmers (e.g. social, economic, technical)?
5. Is the rat control campaign organized by the DAE effective in reducing damage?

Study Site

Testing will be done at two separate sites, Tangail and Ishurdi. Tangail is mainly a deepwater (broadcast) aman rice growing area, and Ishurdi a transplanted aman area. The density of farm families is an estimated 115/km² and 26/km², respectively. These two sites were used in a previous study to determine the seasonal trends in rat density as they related to the cropping pattern (Sultana and Jaeger, 1989); therefore background information is available upon which to base the experimental design in the present study. Aman rice represented about 60 percent of the cultivated land at both sites, and the density of rat burrow systems was also similar at an estimated 25/ha of rice.

Experimental Design

This study is designed to provide statistically meaningful comparisons among treatments, between treatments and controls, and between study sites. Due to the range and mobility of rats and thus the potential for re-invasion of treated areas from surrounding untreated areas, and to the clumped nature of rat distribution and damage as it affects statistical variance, the study sites must be sufficiently large in area and the sample sizes sufficiently high in number. In this study, each geographical site consists of 48 x 1 km² blocks (4800 ha) arranged as 1 km² blocks along both sides of a 24 km transect of road.

Each site is divided into two strata of equal size from each of which 2 x 1 km^2 blocks (4 x 1 km^2 blocks/site) will be randomly selected for treatment by the following applications:

(1) Individual farmers.

(2) Representative of a group of farmers.

(3) Total control.

(4) No control.

Two treatments will be compared: fumigation with Phostoxin vs. baiting with zinc phosphide. These will be equally divided among the 12 x 1 km^2 blocks/site in which treatments are made by (1), (2) or (3), above. Total control by VPS/BARI professionals consists of locating every active burrow system within the 1 km^2 block and placing either the bait cake or fumigant tablet in the most recent burrow opening, and in the case of the fumigant, sealing all of the openings of the burrow system. Farmers and farmer representatives will be instructed to follow the same procedure. At both the time of treatment and at harvest the number of rat burrow systems, crop type and field size will be randomly sampled in 8 x 1 ha plots/ km^2. Figure 1 illustrates the experimental design. By pooling 1 km^2 blocks between study sites and among applications, the following comparisons are possible:

(1) (n = 8) vs. (2) (n = 8)

(1) (n = 8) vs. (3) (n = 8)

(1) (n = 8) vs. (4) (n = 8)

(2) (n = 8) vs. (3) (n = 8)

(2) (n = 8) vs. (4) (n = 8)

(3) (n = 8) vs. (4) (n = 8)

Phostoxin (n = 12) vs. zinc phosphide (n = 12).

Site 1 farmers (n = 8) vs. Site 2 farmers (n = 8)

The dependent variables used in these comparisons fall into two general classes:

1. Rat damage at harvest:
   (a) Number of rat burrows/ha of rice.
   (b) Number of rat days in rice from treatment to harvest (x75 g rat/day equals projected damage).
   (c) Cost:benefit ratio of treatment.
2. Farmer participation:
   (a) Number of farmers who agree to the need for preharvest rat control.
   (b) Number of participating farmers.
   (c) Number of farmers who understand the methodology and its safe application.

This sampling design also allows for ranking the constraints on the farmer to participating in rat control. This is done through interview. Constraints fall into the following classes:

1. Social or religious, e.g.:
   (a) Not a traditionally acceptable activity.
   (b) Religious objection to killing.
   (c) Undignified activity.
   (d) Cooperation of neighbors difficult to obtain.
2. Economic, e.g.:
   (a) Unaffordable.
   (b) Not cost-effective.
3. Extension, e.g.:
   (a) Lack of information and understanding about the problem and the means of control.
4. Commercial rat control products, e.g.:
   (a) Lack of reliable way to kill rats.

114

Field Schedule

1. Site preparation, establishment of local contacts (political, extension, farmers), and making local labor arrangements:

   Ishurdi: 15 - 25 August, 1989

   Tangail: 1 - 11 September, 1989

2. Training of farmers, distribution of rat control products, control treatments, and sampling rat density and cropping patterns:

   Ishurdi: 21 September - 5 October, 1989

   Tangail: 13 - 27 October, 1989

3. Aman harvest, final assessment of rat numbers, and post-study farmer interviews:

   Ishurdi: 15 - 30 November, 1989

   Tangail: 7 - 21 December, 1989

Consultancies

1. Bangladeshi consultant to survey prospects for business opportunities and to recommend how best to distribute and market rodenticides.
2. Bangladeshi consultant to evaluate socio-economic constraints on farmers related to rat control.
3. USDA extension specialist to assist in training and interviewing of farmers.

PL-480 Budget Requirements

1.	Purchase of rodent control chemicals and preparation of baits.	Taka 24,500
2.	Equipment and supplies	10,000
3.	Training farmers	36,000
4.	Local labor and technical assistance	15,000

Figure 1. Experimental design illustrating treatments in 16 x 1 km² blocks at each of two study sites.

SITE 1 Stratum A	SITE 1 Stratum B	SITE 2 Stratum A	SITE 2 Stratum B	Application
				No Control (n = 8)
Zn	Ph	Zn	Ph	Total Control (n = 8)
Ph	Zn	Ph	Zn	
Zn	Ph	Zn	Ph	Individual (n = 8)
Ph	Zn	Ph	Zn	
Zn	Ph	Zn	Ph	Group Representative (n = 8)
Ph	Zn	Ph	Zn	

Farmer Application

Zn = Zinc phosphide
Ph = Phostoxin

5.	Transport (ferry, local boats, train, plane)	Taka 7,500
6.	Fuel for vehicles	5,000
7.	Preparation of VCR documentary	9,000
8.	Local consultancies	60,000
9.	Per diems	6,000
10.	Typing, photocopy, etc.	5,000
	Total:	Taka 178,000

References

Adhikarya, R. and Posamentier, H. (1987). Motivating farmers for action: How strategic multi-media campaigns can help. GTZ No. 185, P. 209.

Poché, R.M. and Mian, M.Y. (1986). Effectiveness of four rodenticides in deepwater rice. In Zeitschrift für Angewandte Zoologie, K. Becker, Ed., pp. 37-49.

Poché, R.M.; Sultana, P.; Mian, M.Y. and Haque, M.E. (1979). Studies with zinc phosphide on Bandicota bengalensis (Gray) and Rattus rattus (Linnaeus) in Bangladesh. Bangladesh J. Zool. 7(2):117-123.

Sultana, P. and Jaeger, M.M. (1989). Control strategy to reduce preharvest rat damage in Bangladesh. Tech. Rept. No. 34, Bangladesh Agricultural Research Institute, Vertebrate Pest Section, Joydebpur, Bangladesh.

Sultana, P.; Brooks, J.E.; Siddique, M.A. and Rahman, M.M. (1981). Comparative toxicities of several anti-coagulant rodenticides to Bandicota bengalensis. Tech. Rept. Bo. 13, Bangladesh Agricultural Research Institute, Vertebrate Pest Section, Joydebpur, Bangladesh.

APPENDIX 7.0

VERTEBRATE PEST COMPONENT WORKPLAN OUTLINE 1986-1991

INTRODUCTION

USAID support of the Vertebrate Pest Component of the Agricultural Research Project (ARP) will be extended for the 4-year period (1987-91) of Phase III. This extension will allow for completion of ongoing research, implementation of the results, and evaluation of additional vertebrate pest problems. The principal objective is to increase food production in Bangladesh through effective vertebrate pest control at the farm level.

At this time it is important to both the Bangladesh Agricultural Research Institute (BARI) and USAID/DWRC that a workplan be agreed upon which outlines the broad research objectives and outputs for the period October 1986 to June 1991. This will promote mutual understanding of the Project's goals and is particularly important because of the arrival of the new project adviser from DWRC. In addition, a long-term workplan will facilitate timely planning for equipment, training, and technical support from DWRC.

The following workplan is directed toward developing technology that is appropriate to the Bangladeshi farmer. Research and extension will be integrated into the overall national Farming Systems Research and Development (FSR&D) activities. Statistically meaningful damage assessments are an important part of this research proposal. These will allow for evaluation of the relative seriousness of vertebrate pest problems under different conditions and whether or not control is effective.

BACKGROUND AND JUSTIFICATION

Since the onset of the Project in late 1978, significant progress has been made in understanding the vertebrate pest problems in Bangladesh and in developing appropriate control technology. Additional research and extension, however, are needed before effective control is realized at the level of the small farm holder.

Developing a program for effective vertebrate pest control involves the following steps:

1. Identify the major pest problems.
2. Develop practical control techniques.
3. Develop a control strategy for when, where, and how to best employ control techniques under local conditions.
4. Implement results.

The importance of Step 3 must be emphasized. The end product of research is not simply a control agent such as a pesticide, a trap, or a chemical repellent. In order for the agent to be effective, it must be used in a manner appropriate to the situation. Factors such as timing and area of application of a treatment often vary with the situation and depend on the pest species, cropping patterns, field sizes, human population demographics, general ecology, and other factors. For instance, Bangladesh is unique in terms of its extensive seasonal flooding that concentrates terrestrial pests on higher ground and, thereby, offers a potential opportunity for long-term control. With regard to the major pest problems in Bangladesh, we are now at Step 3 where it is necessary to develop control strategies.

The Project has identified the major vertebrate pest problems in Bangladesh to be, in order of importance:

1. Preharvest rat damage to ripening wheat and rice.
2. Postharvest mouse and rat damage in grain stores in farmers' houses.
3. Jackal damage to sugarcane, chickens, fruits, and vegetables.
4. Bird damage to sprouting wheat and rice.

Problems of lesser impact include:

5. Preharvest bird damage to maize and sunflower.
6. Postharvest bird damage to drying grain.

In addition, problems are reported with porcupines, fruit bats, wild pigs, squirrels, deer, elephants, and primates in a wide variety of crops. Losses due to vertebrate pests in Bangladesh are greatest at the small-farm level.

Vertebrate pest problems are characteristically complex, often requiring years of research before effective management is achieved. For example, research efforts on the major bird pest in Africa have been ongoing for more than 20 years. Similar examples exist worldwide for a variety of other vertebrate pests, including rodents and coyotes. Similarly, there are no quick solutions to the vertebrate pest problems of Bangladesh. Developing a control strategy requires extensive fieldwork where damage levels and pest numbers are monitored with and without control measures and over representatively large areas.

In order to achieve tangible results within the lifetime of the extension, it will be necessary to make the most efficient use of the available time and manpower. This is done by first focusing efforts on

completing work on the most important problems, before beginning new ones. Secondly, research should follow a logical progression as suggested by the four steps for effective vertebrate pest control listed above. Thirdly, a workplan should be prepared scheduling the various research components. The workplan that follows is a product of inputs from the professional staff of the Vertebrate Pest Control Laboratory, BARI. Each of the three Senior Scientific Officers will be responsible for a major problem area.

WORKPLAN SCHEDULE

The objective of the Project's research is to increase food production in Bangladesh by significantly reducing losses to vertebrate pests. This 5-year workplan is designed to meet this objective on a limited, but practical scale. Emphasis will be on fieldwork. Two large study areas will be identified, representing the two ecological zones in Bangladesh where cereal production is concentrated--wet plains and dryland. The different pest problems will be studied in each study area. This will allow for evaluation of how the different problems are interrelated and of the opportunities for integrated management.

The schedule of fieldwork is presented in Table 1. Field research is divided into three categories: baseline, test, and implementation. Baseline refers to the initial year of each study where data are collected on pest numbers and damage levels before control. This provides a reference against which to compare the effectiveness of subsequent treatments. In addition, this period allows for an opportunity to evaluate the experimental design and methods and to make modifications wherever necessary. Next, the control strategies are tested over a 2-year period,

121

Table 1. Workplan schedule for vertebrate pest field research (1986-91).

Problem area	Year 1	2	3	4	5
1. Rat damage to rice and wheat	Baseline	Test	Test	Implementation	
2. Mouse and rat damage in stores	Baseline	Test	Test	Implementation	
3. Jackal damage	Baseline	Baseline	Baseline	Test	Implementation
4. Bird damage in wheat and rice	-[a]	Baseline	Test	Test	Implementation
5. Bird damage to maize and sunflower	-	-	-	-	Baseline
6. Postharvest bird damage	-	-	-	-	Baseline
7. Others	-	-	-	-	Baseline

[a] Dash (-) indicates information will be collected as time and opportunities permit.

and evaluated in terms of reduction in both damage and pest numbers, cost effectiveness, and acceptability to the farmers. This is followed by a year of extension and implementation where the most effective control strategies are introduced to the farmers. Because of limited manpower, the scheduling of research on the different problem areas is staggered. Problems 1, 2, and 3 are begun first, and problem 4 will begin the following year. The remaining problems will be initiated in year 5 and carried on beyond the life of the project.

Table 2 presents the schedule of research to be carried out at the Project's headquarters at BARI, Joydebpur. At the onset, a critical review of each problem will be prepared. Reviews will include available information on the locations and cropping patterns of susceptible crops in

122

Bangladesh, estimates of the damage, important pest species, and the existing control strategies. Laboratory and field station testing of control methods will continue to be an ongoing activity. Data will be analyzed regularly and presented in annual reports. Data processing and statistical interpretation will be reviewed by a statistician in years 2 and 4. Final reports of studies 1 and 2 will be completed in year 4, and of studies 3 and 4 in year 5.

Table 2. Laboratory workplan schedule (in years) for vertebrate pest research (1986-91).

Activity	Problem area[a]						
	1	2	3	4	5	6	7
Literature review	1	1	2	2	4	4	
Prepare collection of study skins	1-5	1-5	1-5	1-5	1-5	1-5	1-5
Test control methods	1	1	1-3	1-2			
Data analysis	2-4	2-4	2-5	3-5	5	5	5
Data review by statistician	2,4	2,4	2,4	4			
Interim report	2,3	2,3	3,4	3,4	5	5	5
Final report	4	4	5	5			

[a]Refer to problem areas listed in Table 1.

EXPERIMENTAL DESIGN

1. Study areas (Fig. 1)

   a. 24-km-long transect[a] along a road in predominant deepwater rice-growing area.

   b. 24-km-long transect along a road in dryland wheat-, rice-, and sugarcane-growing area.

2. Variables

   a. Independent

      - treatments (methods, area, timing)
      - cropping seasons
      - study areas

   b. Dependent

      - pest numbers
      - crop damage levels

3. Sampling methods

   a. Sampling design

      - The sampling unit will be 1-km^2 blocks along both sides of a 24-km-long section of road (total 48 1-km^2 blocks).

---

[a]Sampling a transect along a road was considered the most practical means of sampling a large area under the conditions of seasonal flooding that exist in Bangladesh.

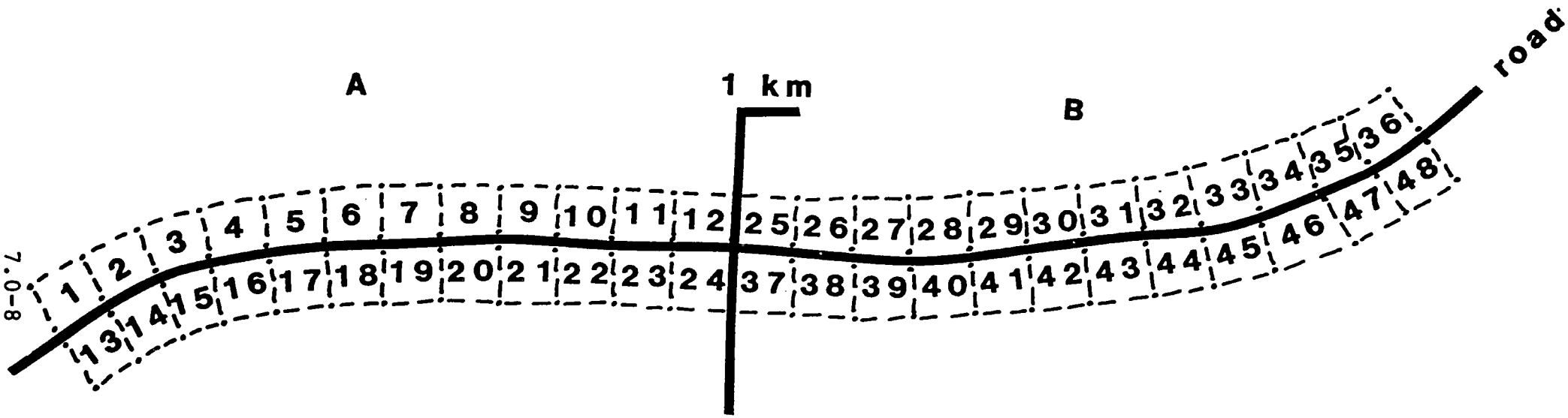


Fig. 1. Scheme for sampling 48 1-km^2 blocks along a 24-km transect of road. Two blocks will be randomly selected each month from each half of the transect (A & B).

- The 24-km-long transect will be divided in half for the purpose of sampling (A & B, Fig. 1), leaving two 12-km-long sections each with 24 1-km^2 blocks.

b. Sampling rodent numbers in fields

- Each month, four 1-km^2 blocks will be randomly selected in each study area (two on either side of the midline, and four different blocks each month for 12 months).

- Within each 1-km^2 block, a suitable 10-ha area containing cultivated fields will be selected.

- Rodents will be sampled within each of the four 10-ha areas each month.

- Therefore, each of the 48 1-km^2 blocks in each study area will be sampled once during the baseline year. During subsequent tests, sampling will be in the same 10-ha areas for each month of the treatment period (see under Treatment design).

- Sampling will be by removal trapping, tracking tiles, and burrow counts.

c. Sampling preharvest rodent damage

- Damage assessments will be undertaken in the same four 10-ha areas in which rodent numbers are sampled or in which control strategies are being tested.

- Damage will be sampled monthly in all susceptible fields within the 10-ha areas.

- Assessment methods used will be those previously developed by the project.

d. Sampling rodent numbers in grain stores in farmers' houses

- Monthly sampling will be in the village nearest each 10-ha area chosen for field sampling.

- Houses will be randomly selected in each village for sampling.

- A combination of removal trapping and tracking tiles will be used to estimate relative abundance and species composition.

- The number of houses/village and traps/house will depend on rodent numbers and the variability in their response to traps and tracking tiles.

e. Sampling rodent damage to grain stores in farmers' houses

- The houses sampled will be the same as those in 3d.

- The volume of each grain type stored will be measured with a tape measure.

- Evidence of rodent damage (droppings, spillage, etc.) will be recorded.

- Preliminary testing is needed in order to determine an accurate measure of losses. One possibility is to place preweighed piles of grain at several locations within a store, including sites where damage is evident and to reweigh for 2-3 days. Grain piles would be placed on, or near tracking tiles.

f. Sampling jackal demographics

- Use 3-year baseline period.

- Use same four 1-km^2 blocks per month as in 3b through 3e during baseline period and sample entire area. Therefore, all 48 1-km^2 blocks will be sampled once per year within each study area.

- Within each 1-km^2 sample block, record evidence of the presence of jackals (i.e., scats, dens, tracks, and damage), as well as that of other mammalian predators (i.e., mongoose).

- Evaluate scent station visits and scat counts as indices of relative numbers.

- Capture and mark jackals during the baseline period to estimate sex, age, and reproductive condition.

- Instrument with a radio transmitter six adult males and six adult females in each study area during each of the first 2 years in order to evaluate longevity, breeding sites, daily activity, home ranges, and seasonal distribution.

g. Sampling jackal damage

- Use the same four 1-km^2 blocks used each month in 3f.

- Estimate the amount of jackal damage to any crop within the blocks, subsampling where necessary.

- Estimate poultry losses by interviewing farmers.

- Analyze scats for evidence of rodents.

h. Sampling numbers of grain-eating birds in fields

- Use the same four 10-ha sample plots used each month for 3b and 3c.

- Observe each 10-ha area for 1 day from 0600 to 0800 and 1600 to 1800 h, recording numbers and species of birds feeding on wheat or rice.

i. Sampling preharvest bird damage to wheat and rice

- Bird damage will be sampled monthly in all susceptible fields within 10-ha areas, in conjunction with rodent damage assessments.

- Assessment methods will be those previously developed by the project.

4. Treatment design

a. Rodent control in fields

- Establish a criterion for the minimum number of rodents present in 10 ha before accepting the plot for treatment or control.

- Treatments are the following:

  - poison baits (B) (i.e., 0.005% brodifacoum) vs tactile (T) poison, where a tactile poison refers to injecting a treated grease into burrows thath rats contact and ingest while grooming;

  - narrow (N) vs wide (W) area control, referring to treating only the infested field vs also treating the surrounding area; and

  - early (E) vs late (L) treatment, referring to applying the treatment either prior to susceptibility or after susceptibility.

- The treatment schedule is illustrated in Fig. 2, and includes the following:

  - three sets of tests per year corresponding to the local cropping pattern (Boro, Aus, and Aman);

  - each test period will be 4 months (treatment--3 months; evaluation--last month);

  - four treatments/test period (BN, BW, TN, NW), each in a separate 1-km^2 block (10-ha area), plus four controls, one 10-ha area in each of the 1-km^2 treatment blocks.

131

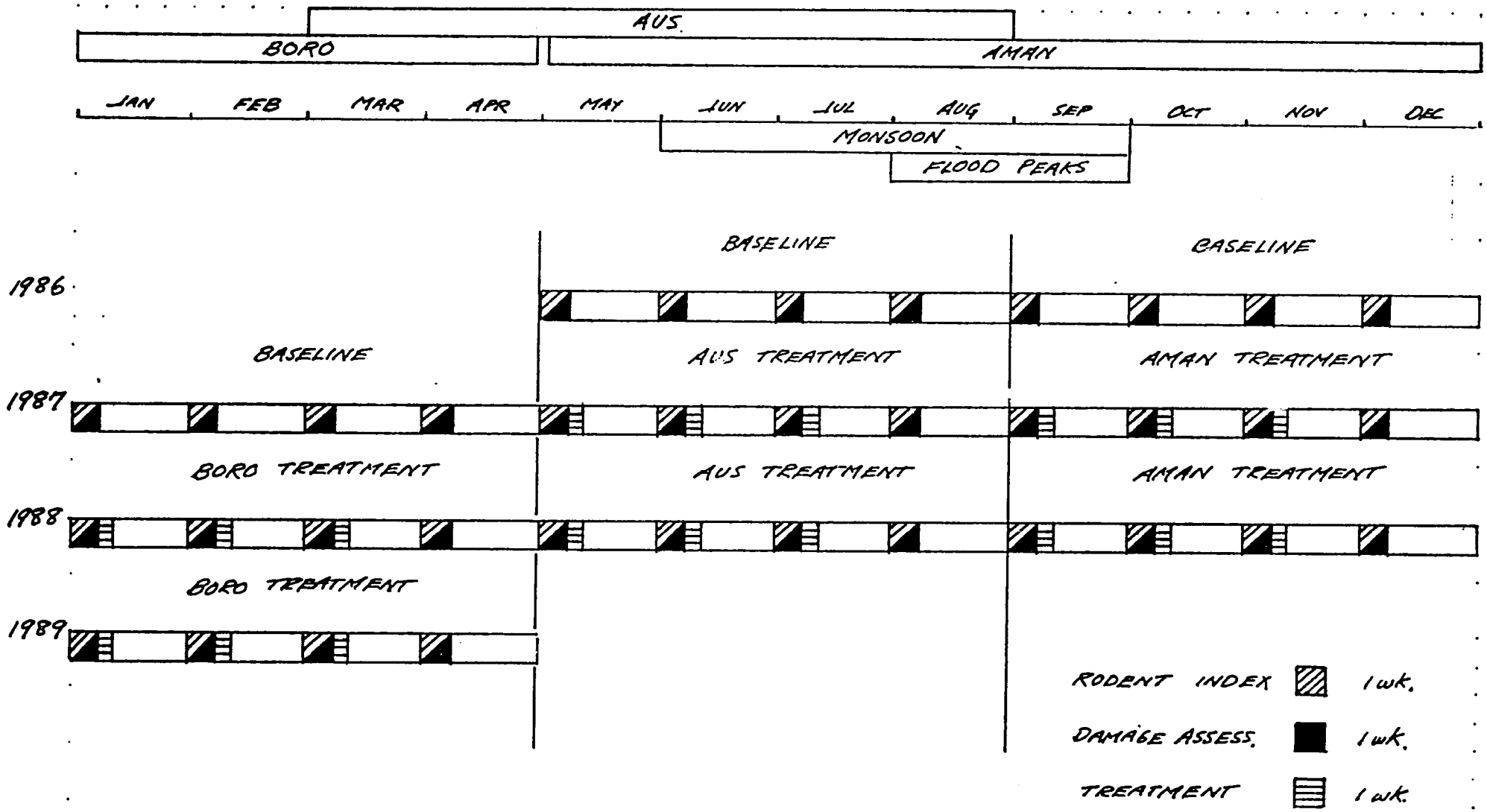


Fig. 2. Scheduling design: preharvest rodent damage.

- Table 3 lists the main components of the test design that will be used for statistical comparisons.

Table 3. Treatments, replications, and statistical comparisons for determining the effects of rodent control in fields and the differences between cropping seasons and study areas.

1. Treatments[a]	No. replications test period	No. test periods	No. study areas	Total no. replications
Bait x Narrow	1	6	2	12
Bait x Wide	1	6	2	12
Tactile x Narrow	1	6	2	12
Tactile x Wide	1	6	2	12
Treatment control	4	6	2	48
Baseline control	4	(3)	2	24

[a]Early vs late application will be evaluated by comparing the reduction in rodent numbers between treatment months (1-2, 2-3, 3-4).

2. Cropping seasons	No. control years	No. study areas	No. controls/ cropping season	Total No. replications
Boro	3	2	4	24
Aus	3	2	4	24
Aman	3	2	4	24

3. Study areas	No. control years	No. cropping seasons/year	No. controls/ cropping season	Total No. replications
Dryland	3	3	4	36
Boro	3	1	4	12
Aus	3	1	4	12
Aman	3	1	4	12
Wet plain	3	3	4	36
Boro	3	1	4	12
Aus	3	1	4	12
Aman	3	1	4	12

b. Rodent control in grain stores in farmers' houses

- Establish a criterion for the minimum number of rodents and/or food consumption before accepting a house for treatment or control.

- Treatments are the following:

  - poison baits (B) vs traps (Tr.);

  - narrow (N) vs wide (W) area control, referring to treating the individual house vs also treating surrounding houses; and

  - early (E) vs late (L) treatment, referring to applying the treatment either before or after the time of greatest vulnerability.

- The treatment schedule is illustrated in Fig. 3 and is similar to that for rodent control in fields (Fig. 2) except that it is out of phase by 2 months in order to evaluate control before and after the expected peaks in storage.

- Statistical comparisons will be similar to those suggested by Table 3.

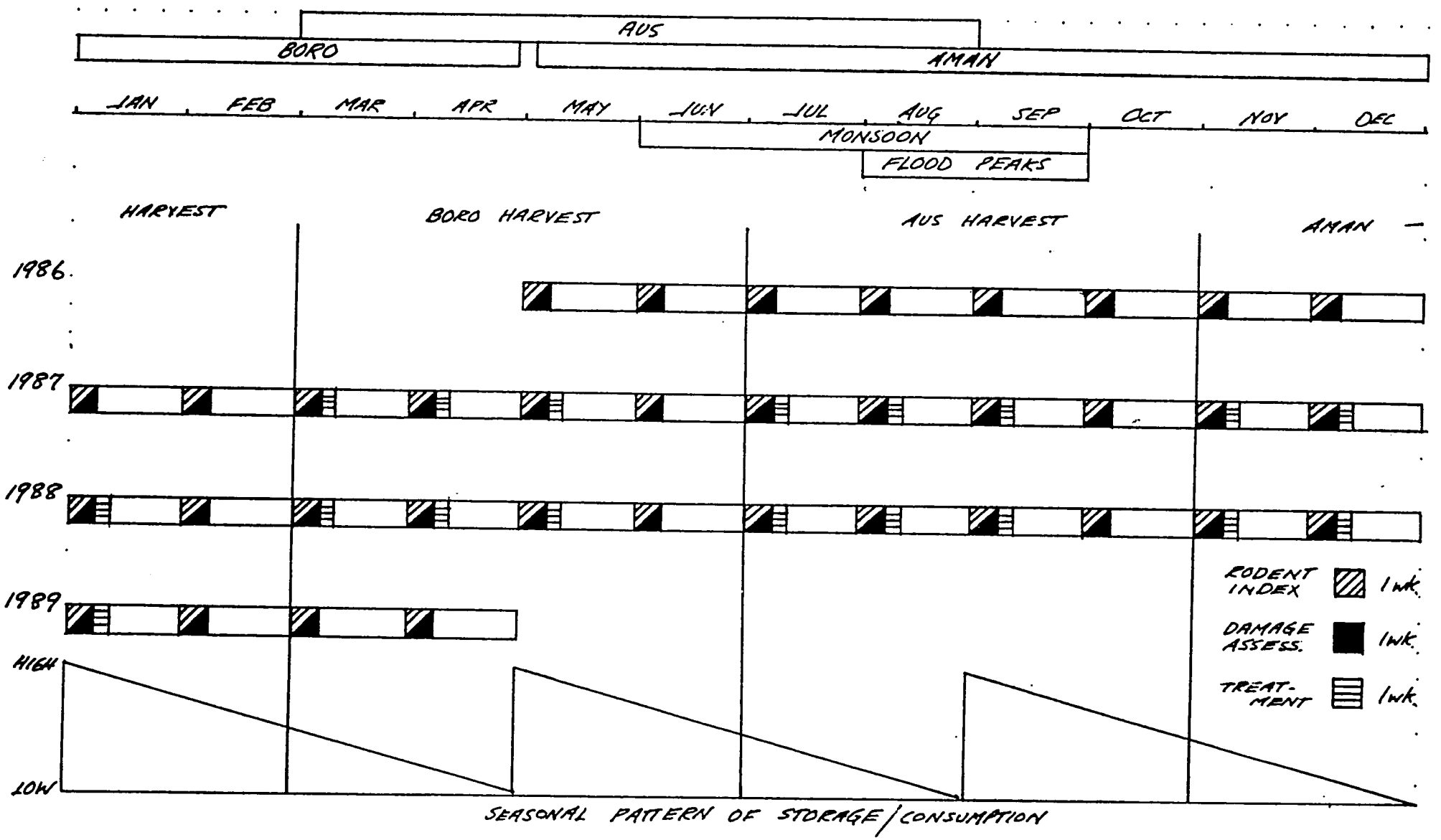


Fig. 3. Scheduling design: postharvest rodent damage.

c. Jackal control

- Establish a criterion for initiating treatment or control based on a minimum number of jackals or minimum damage level.

- Treatments will be determined from baseline findings and lab testing conducted during the first 3 years.

d. Control of preharvest bird damage in wheat and rice

- Establish a criterion for initiating treatment or control based on a minimum number of birds in fields or minimum damage level.

- Treatments are the following:

  - chemical repellent I (i.e., Sevin) vs chemical repellent II (i.e., Marshal); and

  - frightening device (i.e., reflecting tape) vs human bird scarer.

- The treatment schedule will be determined after evaluating the baseline results.

5. Outputs

a. As a result of the above research, recommendations will be made on the following for various conditions existing in Bangladesh:

- censusing techniques for each of the major pests;

- techniques for assessing both pre- and postharvest losses in statistically meaningful ways;

- control strategies for each of the major pest problems; and

- extension needs.

b. In addition, valuable information will be gathered on the following:

- the nature of each of the major vertebrate pest problems in terms of cropping patterns, species composition, and seasonal demographics of the pests, crop damage, crop production, and existing rodent control practices and their effectiveness; and

- research tactics for solving vertebrate pest problems.

CONSULTANCIES

Need for the following consultancies/TDYs from DWRC is foreseen in order to assist with the workplan:

1. Statistician, to assist with:

   1986 - Installation of IBM-AT computer and instructions on its use.

   1988 - Interim review of data collection, analysis, and interpretation.

   1990 - Final data analysis and interpretation.

2. Wildlife biologist/radio tracking specialist, to assist with:

   1986 - Initial radio-tracking of jackals.

   1987 - Radio-tracking of rats in the field to determine their behavior toward control methods.

   1988 - Study of secondary hazards associated with rodent control.

   1989 - Study of secondary hazards associated with jackal control.

   1990 - Initial study of the roosting, daily movements, and feeding behavior of fruit bats.

EQUIPMENT AND FACILITIES

The following needs for additional equipment are foreseen in the next 5 years:

1. 1986

   - 4 x 4 vehicle (2)
   - IBM 3270 AT computer with accessories (1)
   - drafting table and supplies for making illustrations
   - video camera for documentation and training
   - specimen cabinets (2 sets)

2. 1989

   - 4 x 4 vehicle (1)

   Needed additions to the laboratory include:

   - store room
   - library-meeting room
   - jackal enclosures

TRAINING AND MEETINGS

The following training needs are foreseen:

1. Ph.D. with emphasis on statistical design and computer use. Research would be conducted in Bangladesh on one of the major vertebrate pest problems.

2. Eight to ten weeks of training for one individual in the U.S. at a coyote research facility.

3. Local training of project staff in the use of computers.

It has also been proposed that an International Workshop on Vertebrate Pest Problems in Southern Asia be held in Dhaka during 1988. This would be organized in cooperation with the USAID/DWRC project in Pakistan. We also recommend that one of the Project staff attend each of the following meetings and present a paper for publication:

1987 - Plant Protection Conference in Manila, Philippines

1988 - Vertebrate Pest Conference in California

1990 - Vertebrate Pest Conference in California

TECHNICAL SUPPORT FROM DWRC

In addition to consultancies, the following technical support will be provided by the DWRC:

1. Development of a toxic grease for control of rats in burrows and mice in grain stores.

2. Development of a practical technique for estimating rodent damage in grain stores.

Prepared by Michael M. Jaeger

September 1986

APPENDIX 8.0

THE IMPACT OF JACKAL PREDATION ON PREHARVEST RAT DAMAGE IN BANGLADESH

Technical Report No. 35

June, 1989

VERTEBRATE PEST SECTION
Division of Entomology
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur
Bangladesh

The Impact of Jackal Predation on Preharvest Rat Damage in Bangladesh

P. SULTANA & M. M. JAEGER

The Golden Jackal (Canis aureus) is the most conspicuous of the mammalian predators found in Bangladesh. The Jungle Cat (Felis chaus) is also common but more secretive (Khan, 1985). Both species are widely distributed in agricultural areas despite intensive cultivation and dense human habitation. Preliminary studies have suggested that jackals may be an important pest of poultry, livestock and a variety of cultivated crops (Haque et al., 1985; Poché et al., 1987). The potential benefit of jackals to rodent control has not been assessed; and rat damage to pre- and postharvest rice and wheat is the country's most serious vertebrate pest problem (Posamentier and Alam, 1980; Poché et al., 1982; Brooks, Sultana and Poché, 1985; Mian, Ahmed and Brooks, 1987; Sultana and Jaeger, 1989). Because of their abundance, rodents are likely to be an important prey base for predators in Bangladesh as they are elsewhere. Small mammals are an important prey item for wild canids in many situations where their food habits have been studied (e.g. Schaller, 1967; Bothma, 1971; Rowe-Rowe, 1976; Lamprecht, 1978; Litvaitis and Shaw, 1980; Andelt, 1985; Grafton, 1985), and similarly for the smaller felids (e.g. Gashwiler et al., 1960; Saunders, 1963; Liberg, 1984). The objectives of this study were to determine whether (1) rodents are an important prey item of jackals in Bangladesh, and if so (2) whether this predation is likely to have an impact on reducing rat damage to preharvest cereals.

METHODS

Scat Collection and Analysis

The jackals' diet was determined by identifying the undigested remains of their excreta (referred to as scats). Scats were collected monthly from November, 1986 through December, 1987 from two 4800 ha study sites in Bangladesh (Fig. 1). These sites represent the two principal agroecological zones where rice, the country's principal cereal crop, is grown: floodplain (Mirzapur) and wet plain (Ishurdi). Each site consisted of 48 x 1 km^2 blocks along both sides of a 24 km road transect. Sites were systematically sampled each month for scats in connection with a separate study to determine the spatial (crop type) and temporal (season) distribution of rat burrow systems in farmers' fields (Sultana and Jaeger, 1989). Additional scats were collected in other non-randomly selected locations within or near each study site. Searches were made away from housing clusters to reduce possible confusion of jackal scats with those of domestic dogs. Confusion seemed most likely to occur between jackals and jungle cats, based on scat comparisons of caged animals fed dead rats. Jackals however were much more frequently sighted in the open, cultivated areas from which scats were collected. At Ishurdi, for instance, 55 jackals were sighted over a five month period compared to five jungle cats, four mongoose (*Herpestes* spp.) and one Bengal Fox (*Vulpes bengalensis*). Similarly, at another study site 85 jackals were spotted over nine complete nights compared with three jungle cats and four Large Indian Civets (*Viverra zibetha*) (Pandit, unpubl.). Scats of the Large Indian Civet and mongoose are readily distinguishable from those of jackals.

In the laboratory, scats were boiled briefly in water and teased apart; the presence of hair, bone, feather, exoskeleton, fish scale and plant material

was noted. Rodent teeth and jaw parts were retained to identify the species from the cusp pattern of the molars and to determine the minimum number of animals represented in each scat.

Seasonal Distribution of Rats

The spatial and temporal distribution of rats in fields was sampled to understand where and when predation might have the greatest impact on reducing preharvest rat damage. Sampling methodology is described in Sultana and Jaeger (1989). The principal rat pest in ripening cereals in Bangladesh is the Lesser Bandicoot Rat, *Bandicota bengalensis* (Poché *et al*., 1982; Brooks, Sultana and Poché, 1985; Poché and Mian, 1986). The Greater Bandicoot Rat (*B. indica*) and the Short-tailed Mole Rat (*Nesokia indica*) are also pests in some situations, while the Roof rat (*Rattus rattus*) is most common around human habitation or where sufficient cover occurs such as sugarcane (Haque *et al*., 1985). These species are principally nocturnal and, with the exception of *R. rattus*, fossorial.

RESULTS

Jackal Diet

Rodent bones were found in 62 percent of the 657 jackal scats analyzed in this study. Rodents were the most important food item by percent occurrence (Fig. 2), followed by bird (31 percent of scats), plant (14 percent), invertebrate (nine percent), fish (three percent) and refuse, which included livestock bones (eight percent). Plant material was most often sugarcane stem or paddy rice. This ranking was the same at both sites. Of the total number of scats examined, 30 percent had the bones of more than one rodent; the most in a single

scat was six (Fig. 3). The overall average was 1.1 rodents/scat which may be an underestimate as rodents of the same size were distinguished only by duplication of the same jaw part. The most commonly identified species were B. bengalensis and R. rattus at Mirzapur and Ishurdi, respectively (Fig. 4). The mole rat N. indica was found only at Ishurdi, supporting the view that this species occurs only in western Bangladesh (Poché et al., 1982). There was a seasonal trend in the percentage of scats with the remains of burrowing rats and of Mus spp. (Fig. 5) with the highest occurrence in the period January to March and the lowest from October to December ($r = -0.98$, $F < 0.025$ for the regression lines of both rats and mice). The mice were probably M. bodooga which also lives in burrows.

Scat Density

Jackals tended to be relatively more abundant at Ishurdi than Mirzapur based on the numbers of scats found in randomly sampled 1 ha plots in cropping areas at each site. (For a description of sampling procedure refer to Sultana and Jaeger, 1989.) The monthly average at Ishurdi was 0.6/ha ± 0.26 (1 S.E.) compared with 0.2/ha ± 0.04 (1 S.E.) at Mirzapur. The highest density was in March at both sites, 2.8 scats/ha at Ishurdi and 0.4 scats/ha at Mirzapur.

Rat Distribution in Ripening Cereals

The detailed results of sampling the spatial and temporal distribution of rat burrow systems are described in Sultana and Jaeger (1989). In brief, there was a seasonal pattern of fluctuation in the monthly density of rat burrow systems that was the same at both sites. An overall peak of 15 - 20 burrows/ha occurred in November - December coincident with the aman rice harvest which is

the main rainfed cereal crop produced in Bangladesh. Thereafter there was a general decline with a secondary peak in March coincident with the maturation of the wheat crop and a tertiary peak in May - June at Mirzapur coinciding with the boro harvest. A seasonal low of $\leq$ 3 burrows/ha occurred from June to September, from prior to flooding until after the peak flooding. Overall burrow density increased sharply at both sites coincident with the maturation of the aman crop, and at the time when the percentage of scats with the remains of burrowing rats was lowest.

Rat burrows tended to be concentrated in those fields where ripening cereals and cover (bunds bordering dense vegetation) were available. The highest concentration of rat burrows in rice was associated with the aman harvest where densities ranged from 18 - 20 burrows/ha. Densities in boro rice reached 7 - 10 burrows/ha; and there was no noticeable peak in aus rice when many fields were flooded at harvest. The highest density was 57 burrows/ha in wheat at Mirzapur, about double that found in wheat at Ishurdi.

The distribution of rat burrow systems was most restricted in wheat which comprised only about 11 percent of the area sampled at both sites; in comparison, aman rice comprised about 60 percent of the area, boro 20 - 30 percent, and aus 35 - 42 percent. Approximately 90 percent of all rat burrows found in March were in wheat. This was the general time when the incidence of burrowing rat remains in jackal scats was greatest.

The distribution of non-burrowing R. rattus was not studied here since prior evidence suggests that this species is not an important pest of preharvest cereals in Bangladesh (Poché et al., 1982; Poché et al., 1986). The greater occurrence of R. rattus in the scats from Ishurdi suggests that they were caught in sugar cane which was much more prevalent at Ishurdi and which jackals

commonly use for daytime cover (Haque and Jaeger, in prep.).

PREDATION MODEL

The objective here is to predict the possible impact jackal predation could have on reducing preharvest damage to wheat by burrowing rats. Wheat was selected as the cropping situation where jackal predation was likely to have the greatest impact for the following reasons:

1. Jackal predation on burrowing rats was greatest during the time of wheat maturation (January - March) based on the incidence of these rats in scats (Fig. 5).
2. Rat burrows were most densely concentrated in wheat where jackals would presumably have to focus their hunting.
3. The relative impact of rat control would be greatest in wheat as the area cultivated was relatively little.
4. This is the season when jackals are denning (Poché et al., 1987) and when their energy requirements would be relatively high.

The first step is to estimate the number of rats consumed by jackals. To do this we will consider what a pair of jackals can eat. Jackals were most often seen in pairs (Haque and Jaeger, in prep.). We assume here that the density of rats increases linearly in wheat over the 45 day period from booting until harvest (refer to Fig. 6, Sultana and Jaeger, 1989) and that, therefore, the average number of rats consumed per day by a pair of jackals will also increase linearly over this period as the rats become more abundant and concentrated. Fig. 6a shows the cumulative numbers of rats removed over this period when captures per day increase from one to three, four, five or six; total removals range from 90.0 to 157.5. As an example of how this was calculated, let

us consider the linear increase of captures per day over 45 days from one to three where T_P represents the total number of rats consumed per pair of jackals and x is equal to the total number of days:

$$T_P = \int_0^{45} (1.0 + x/22.5)dx = 90.$$

In order to interpret what the total number of rats removed means in terms of damage reduction, it is necessary to determine the number of rat days in wheat that this represents. Damage then can be approximated by multiplying the number of rat days by an average amount of wheat removed per rat per day. Figure 6b shows the cumulative number of rat days saved per pair of jackals over the 45 day damage period based on linear increases of from one to three, four, five or six rats consumed per day. Again using the example of the increase from one to three rats per day, the total number of rat days saved, T_D was determined by:

$$T_D = \int_0^{45} [(1.0 + x/22.5)(45 - x)]dx = 1687.5$$

At the levels of four, five and six rats per day, T_D was 2025.0, 2362.5 and 2700.0 respectively. Assuming that a rat destroys and average of 75g of wheat per day (Sultana and Jaeger, 1989), these values of T_D represent savings of 126.6, 151.9, 177.2 and 202.5 kg of wheat per pair of jackals, respectively.

What do these savings represent relative to the rat damage in wheat? Let us assume a jackal density of one pair per km^2 during this time (Haque and Jaeger, in prep.; Pandit, unpubl.). The area of wheat at Ishurdi was estimated to be 11.9 percent of the total area under cultivation (Sultana and Jaeger, 1989), or 11.9 ha/km^2. The density of rats in wheat at Ishurdi at the beginning and the end of the 45 day damage period was estimated at 5.6 and 21.9 per ha of wheat,

respectively. Assuming a linear increase in rat numbers/ha of wheat over this damage period, the number of rat days in wheat in 1 km² of farmland, T_R is:

$$T_R = \int_0^{45} [11.9(5.6 + x/2.76)]dx = 7362.7.$$

This represents 552.2 kg/km² of wheat lost to rats at 75g/rat/day. Therefore, without jackal predation the damage could have been 22.9, 27.5, 32.1 and 36.7 percent greater, respectively. This model suggests that jackal predation may substantially reduce preharvest rat damage to wheat.

DISCUSSION

Results of both scat analysis and the model of jackal predation in wheat suggest that predation may be an important biological check on field rats in Bangladesh. It is reasonable to assume that rodents are an important food base for a variety of predators in Bangladesh, including reptiles, birds and mammals. Empirical evidence suggests that even daytime predation of generally nocturnal rats occurs when there is sufficient cover for the rats to remain active and when the opportunuty exists for hoarding ripening panicles of wheat or rice. For instance, B. bengalensis have been observed to forage during the day, making numerous short trips from burrow openings and returning with panicles (Jaeger, pers. obs.). Diurnal birds of prey (e.g. the Black-shouldered Kite, Elanus caeruleus) have been seen to capture rats in fields of ripening cereals (Jaeger, pers. obs.). In addition, jackals and jungle cats have the opportunity to prey on rats both night and day as these predators use daytime cover in which rats are abundant (e.g. sugarcane and mature rice and wheat) (Haque and Jaeger, in prep.).

Predation offers an explanation for the regular seasonal decline in the

numbers of burrowing rats in Bangladesh (Sultana and Jaeger, 1989). This is suggested by the apparent seasonal relationships of both burrow density (positive) and the incidence of burrowing rats in jackal scats (negative) with the decline and rise, respectively, in the occurrence of vegetative cover for rats. The peak density in burrowing rats, the predominant type of rat found in farmlands, occurs in December when food and vegetative cover are the most widespread and when the hours of dark per night are greatest. The density in rat burrow openings declines sharply following the aman harvest and plowing, but it recovers to a secondary peak in March coincident with the regrowth of cover and food provided by winter crops of pulses, potatoes and wheat. By the onset of the monsoon rains in June, rat density in the fields has declined to only one to two adults per hectare and remains around this level until the end of the monsoon in September - October when recovery begins coincident with the recession of flood waters and the re-occurrence of dense cover provided by the main aman rice crop.

A greater jackal density at Ishurdi may account, in part, for the lower rat density there in wheat compared with Mirzapur. Overall rat density in fields was the same at both sites in December when rat density was at its seasonal peak; however by the time of wheat harvest in March, rat density in wheat at Mirzapur was 57/ha compared to 22/ha at Ishurdi, while the relative area of wheat at each site was similar (Sultana and Jaeger, 1989). The greater human density (Mian, unpubl.), extensive seasonal flooding, and the almost total absence of cover such as sugarcane may all be reasons for a lower jackal density at Mirzapur.

The predominance of burrowing species of rodents (e.g. B. bengalensis and M. bodooga) in the intensively cultivated farmlands of Bangladesh also supports the importance of cover and predation as selective forces. Non-burrowing species such as R. rattus and M. musculus are more restricted to sugarcane fields and

housing clusters where they take cover in the structures and surrounding trees.

The results of this study suggest that damage by jackals is principally to poultry, and that this may be substantial. Bird remains were the second most common food type found in scats. No attempt however was made to distinguish among chickens, ducks and wild birds; although many of the remains were obviously of domestic birds. Also it was not possible to know the proportion of bird remains that had been scavenged from refuse middens versus those resulting from predation.

This study points to the need for further research to determine at what population levels and under what agroecological circumstances the benefits of jackals outweight the damage to poultry. The ultimate goal is to be able to manage the populations of both predators and prey in order to optimize the long-term benefits of predation.

ACKNOWLEDGMENTS

We thank Dave Otis for all of his help with the sampling procedure and modeling, Paige Groninger and Michelle Tudor for preparing the computer graphics and Margaret Jaeger for typing the original manuscript.

Funds were provided by USAID under the project "Agricultural Research II Vertebrate Pest Management Component, PASA IBD-0051-P-IF-2252-05".

REFERENCES

Andelt, W.F., 1985. Behavioral ecology of coyotes in south Texas. Wildl. Monogr. 94, 45 pp.

Bothma, J. Du P., 1971. Food of Canis mesomelas in South Africa. Zoologica Africana 6(2):195-203.

Brooks, J.E., Sultana, P. and Poché, R.M., 1985. Damage by Bandicota bengalensis to growing wheat in Bangladesh and methods of control. Acta Zool. Fennica 173:135-137.

Gashwiler, J.S., Robinette, W.L. and Morris, O.W., 1960. Food of bobcats in Utah and Eastern Nevada. J. Wildl. Mgmt. 24:226-229.

Grafton, R.N., 1965. Food habits of black-backed jackals: A preliminary report. Zool. Afr. 1:41-53.

Haque, M.E., Ahmed, S., Pandit, R.K., Karim, M.A. and Brooks, J.E., 1985. Assessment of sugarcane damage by jackal and rat in Sripur area of Bangladesh. Bangladesh J. Sugarcane 7:47-51.

Khan, M.A.R., 1985. Mammals of Bangladesh. Nazma Resa, House 25, Road 1, Dhanmondi, Dhaka 5, Bangladesh, 92 pp.

Lamprecht, J., 1978. On diet, foraging behaviour and interspecific competition of jackals in the Serengeti National Park, East Africa. Z. Säugetierk 43:210-223.

Liberg, O., 1984. Food habits and prey impact by feral and house-based domestic cats in a rural area of southern Sweden. J. Mammal. 65(3):424-432.

Litvaitis, J.A. and Shaw, J.H., 1980. Coyote movements, habitat use, and food habits in southwestern Oklahoma. J. Wildl. Mgmt. 44(1):62-68.

Mian, M.Y., Ahmed, M.S., and Brooks, J.E., 1987. Small mammals and stored food losses in farm households in Bangladesh. Crop Protection 6(3):200-203.

Poché, R.M. and Mian, M.Y., 1986. Effectiveness of four rodenticides in deep-water rice. Z. Angew. Zool. 23(1):37-48.

Poché, R.M., Evans, S.J., Sultana, P., Haque, M.E., Sterner, R. and Siddique, M.A., 1987. Notes on the golden jackal (Canis aureus) in Bangladesh. Mammalia 51(2):259-270.

Poché, R.M., Mian, M.Y., Haque, M.E. and Sultana, P., 1982. Rodent damage and burrowing characteristics in Bangladesh wheat fields. J. Wildl. Mgmt. 46(1):139-147.

Poché, R.M., Mian, M.Y., Sterner, R., Haque, M.E. and Sultana, P., 1986. Rodent movements in wheat fields. Mammalia 50(2):165-172.

Posamentier, H. and Alam, S., 1980. Rodent damage and control in wheat in Bangladesh during the 1980 season. Bangladesh J. Zool. 8(2):99-101.

Rowe-Rowe, D.T., 1983. Black-backed jackal diet in relation to food availability in the Natal Drakensberg. S. Afr. J. Wildl. Res. 13:17-23.

Saunders, J.K., 1963. Food habits of the lynx in Newfoundland. J. Wildl. Mgmt. 27:384-390.

Schaller, G.B., 1967. The Deer and the Tiger. University of Chicago Press, Chicago, IL. 370 pp.

Sultana, P. and Jaeger, M.M., 1989. Control strategy to reduce preharvest rat damage in Bangladesh. Technical report No. 34, Vertebrate Pest Section, Bangladesh Agricultural Research Institute, Joydebpur, Bangladesh.

FIGURE CAPTIONS

Figure 1. Map of Bangladesh illustrating the location of the two study sites, Ishurdi and Mirzapur, from which jackal scats were collected and at which a collaborative study on burrowing rats was conducted (Sultana and Jaeger, 1989).

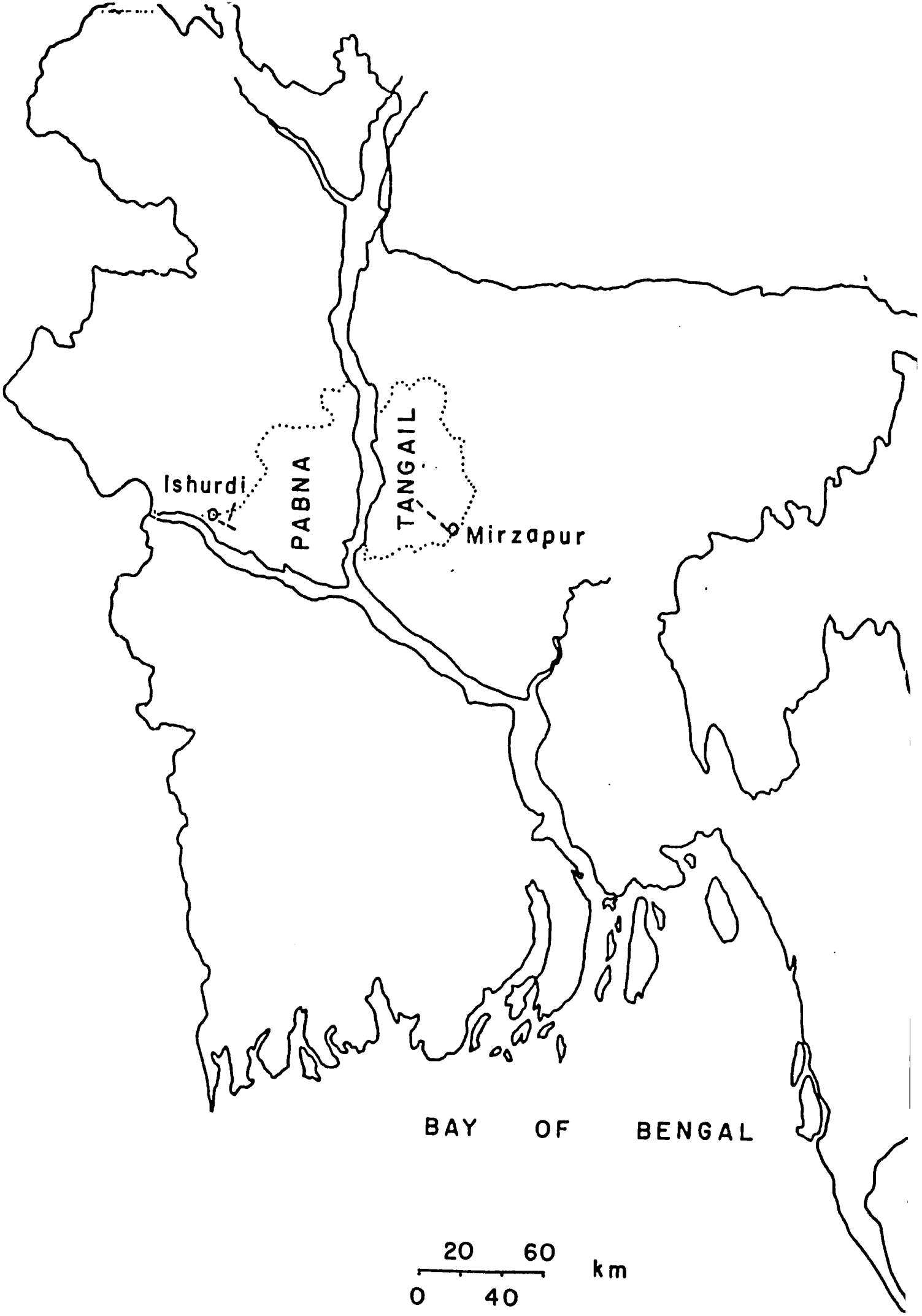
Figure 2. The relative incidence of different food types found in jackal scats collected monthly at Ishurdi and Mirzapur, Bangladesh from November, 1986 to December, 1987.

Figure 3. The relative frequency of jackal scats in which the remains of from zero to seven separate rodents were identified.

Figure 4. Species composition of rodents found in jackal scats.

Figure 5. Seasonal patterns in the occurrence of different types of rodents in the scats of jackals.

Figure 6. Model illustrating the potential numbers of rats consumed by a pair of jackals and the number of rat days saved over the 45 day period from booting to harvest in wheat.



8.0-14

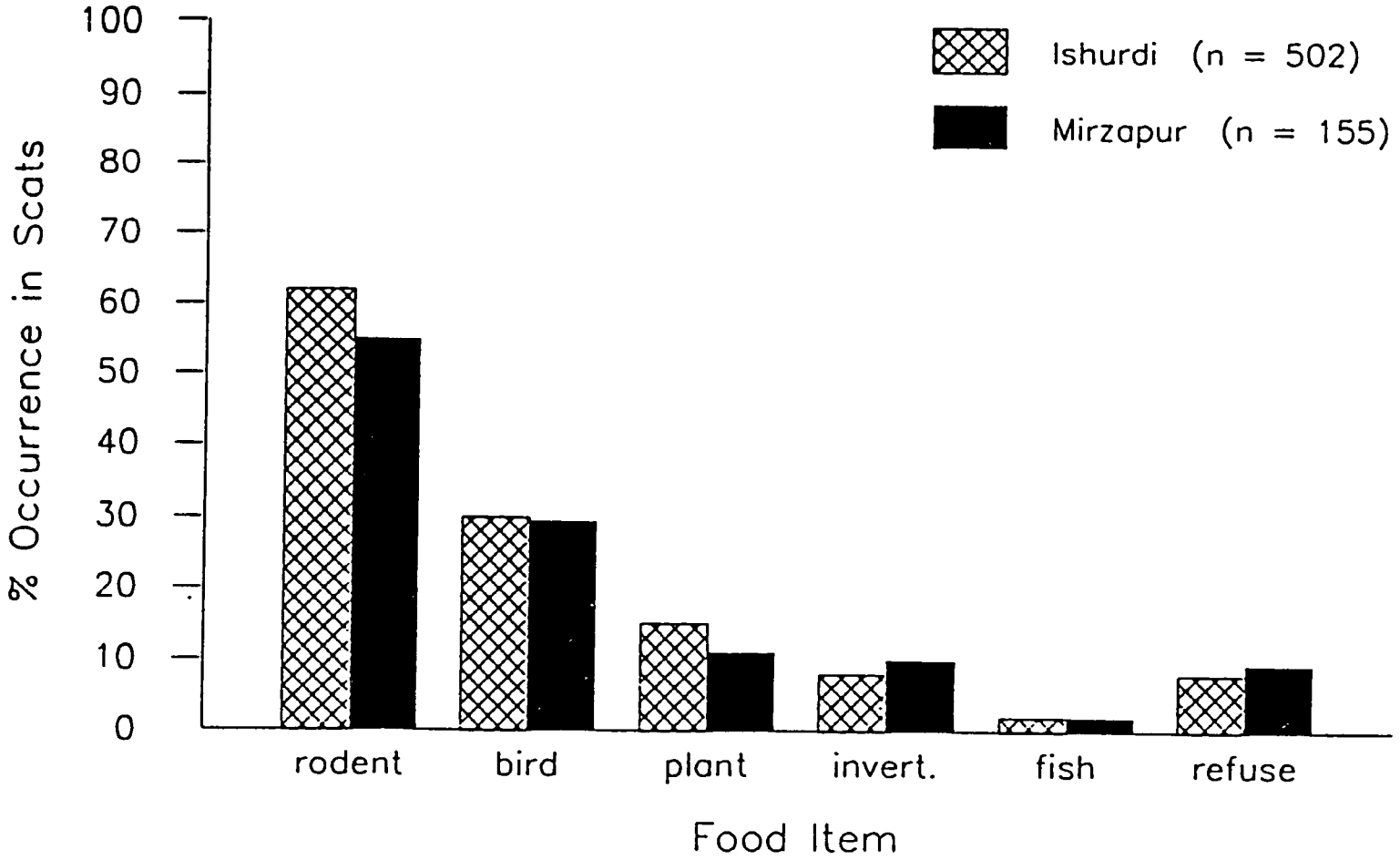
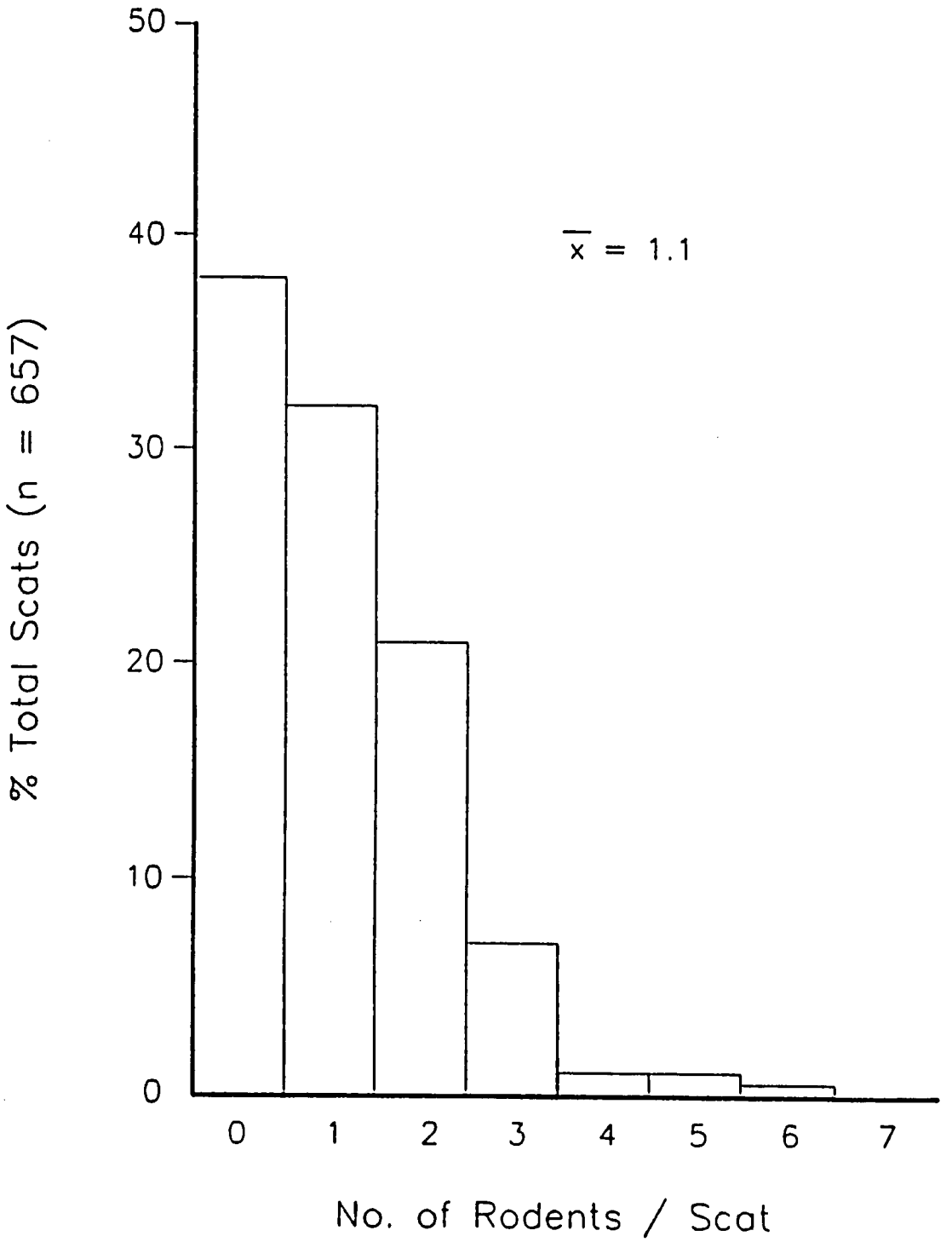

100
90
80
70
60
50
40
30
20
10
0
% Occurrence in Scats
Ishurdi (n = 502)
Mirzapur (n = 155)
rodent
bird
plant
invert.
fish
refuse
Food Item

Fig 2

Fig 3


50
40
30
20
10
0
% Total Scats (n = 657)
$\overline{x}$ = 1.1
0
1
2
3
4
5
6
7
No. of Rodents / Scat

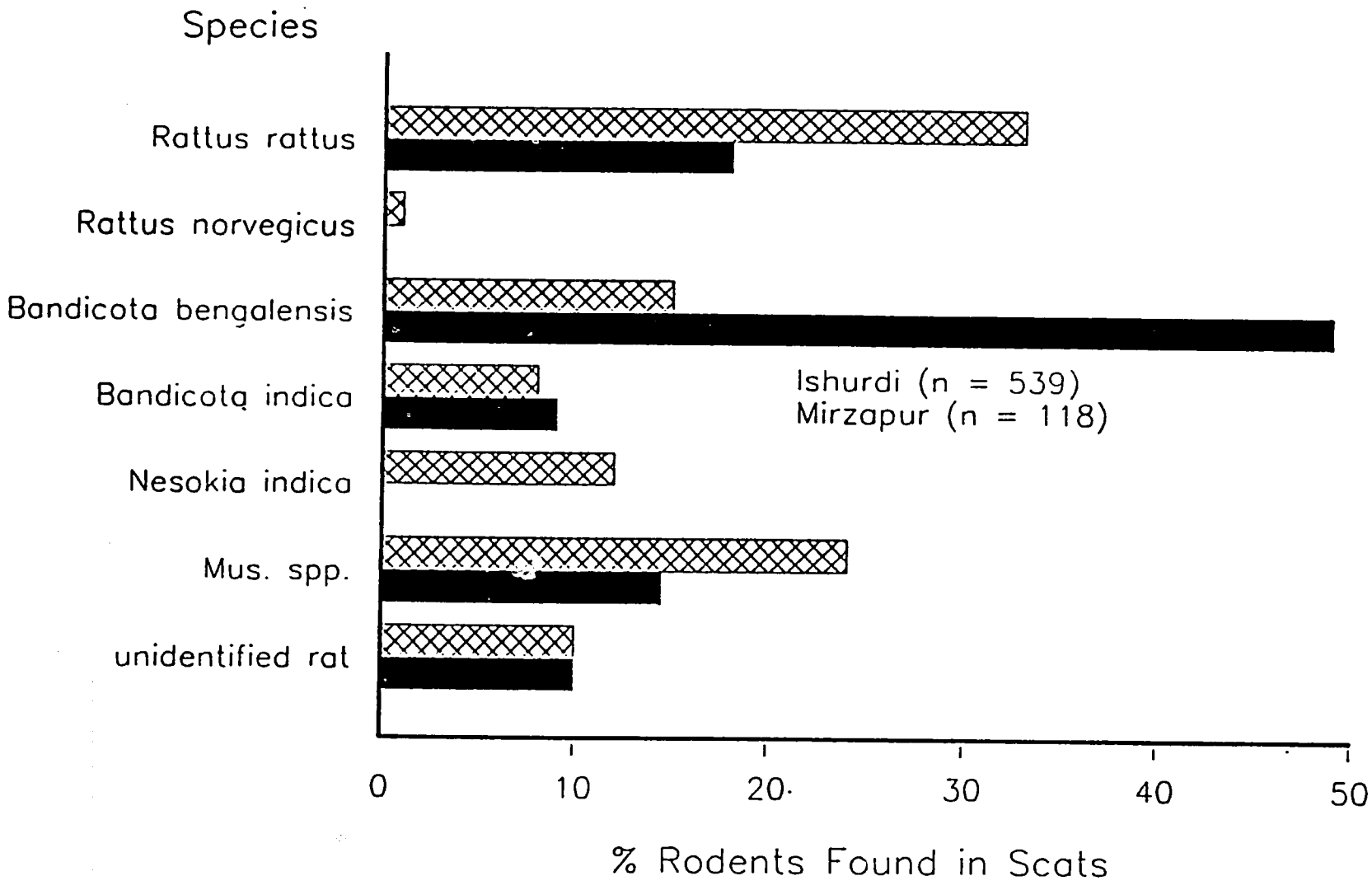
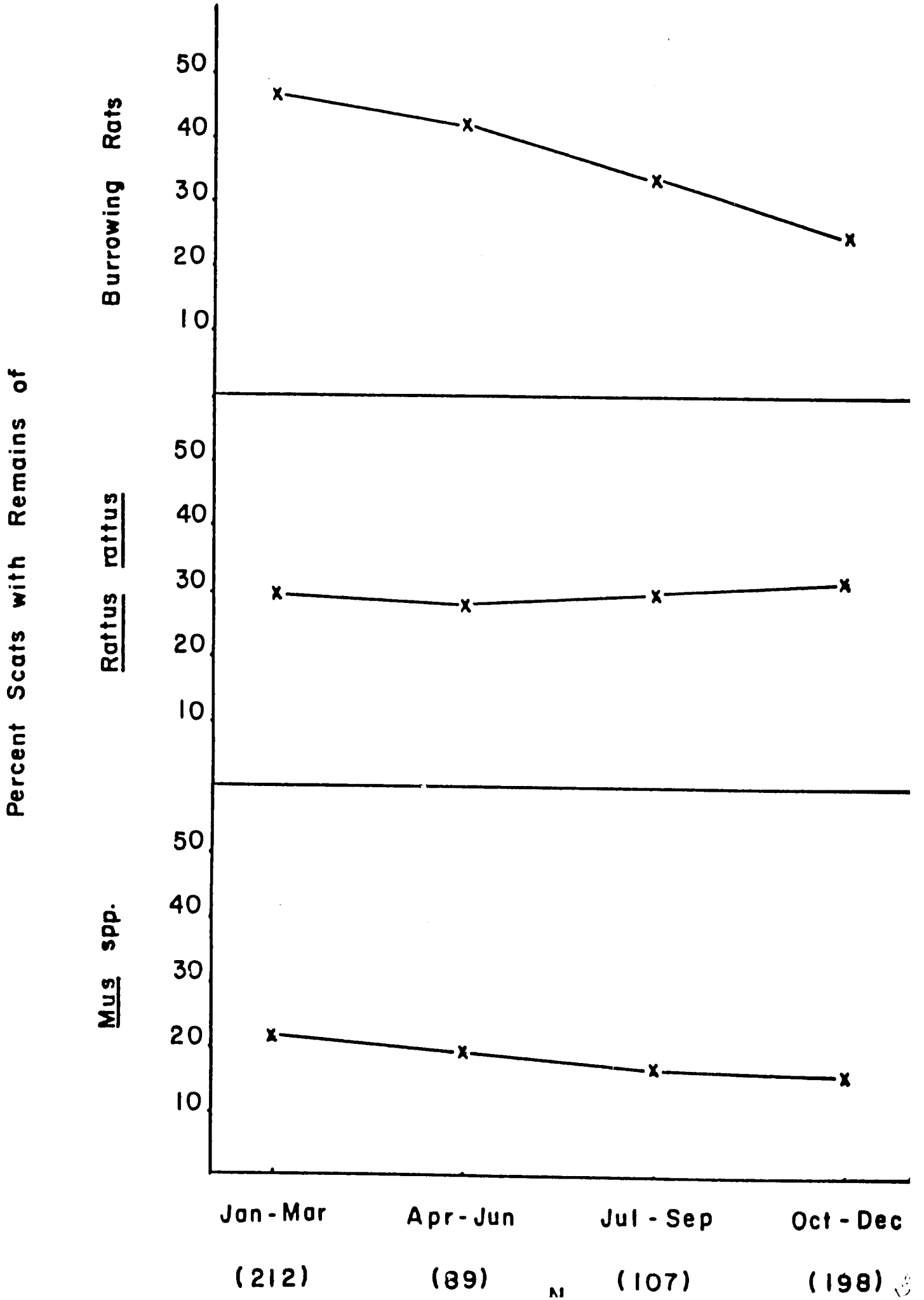
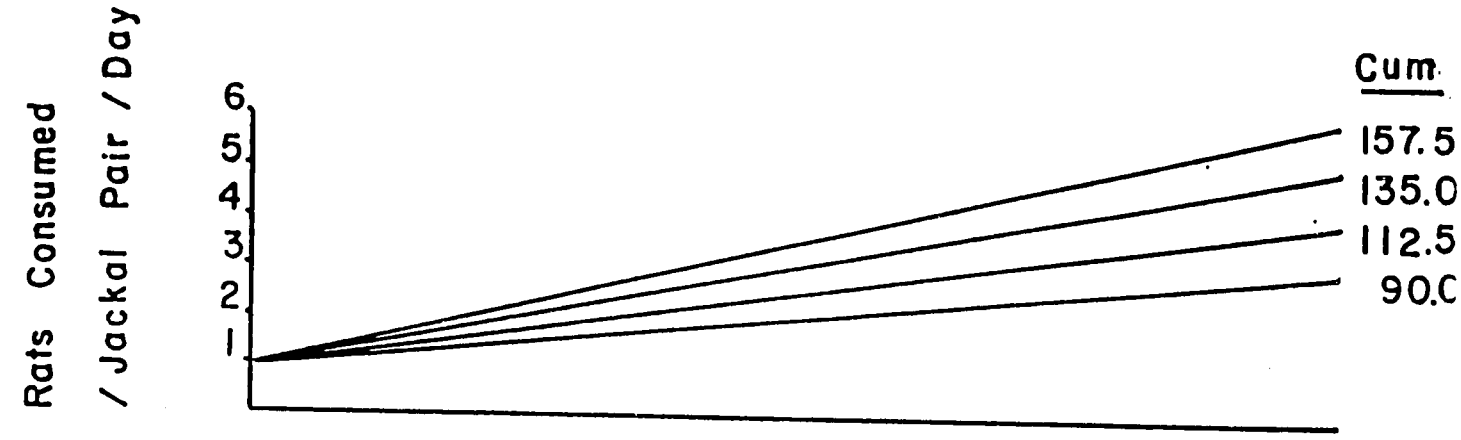
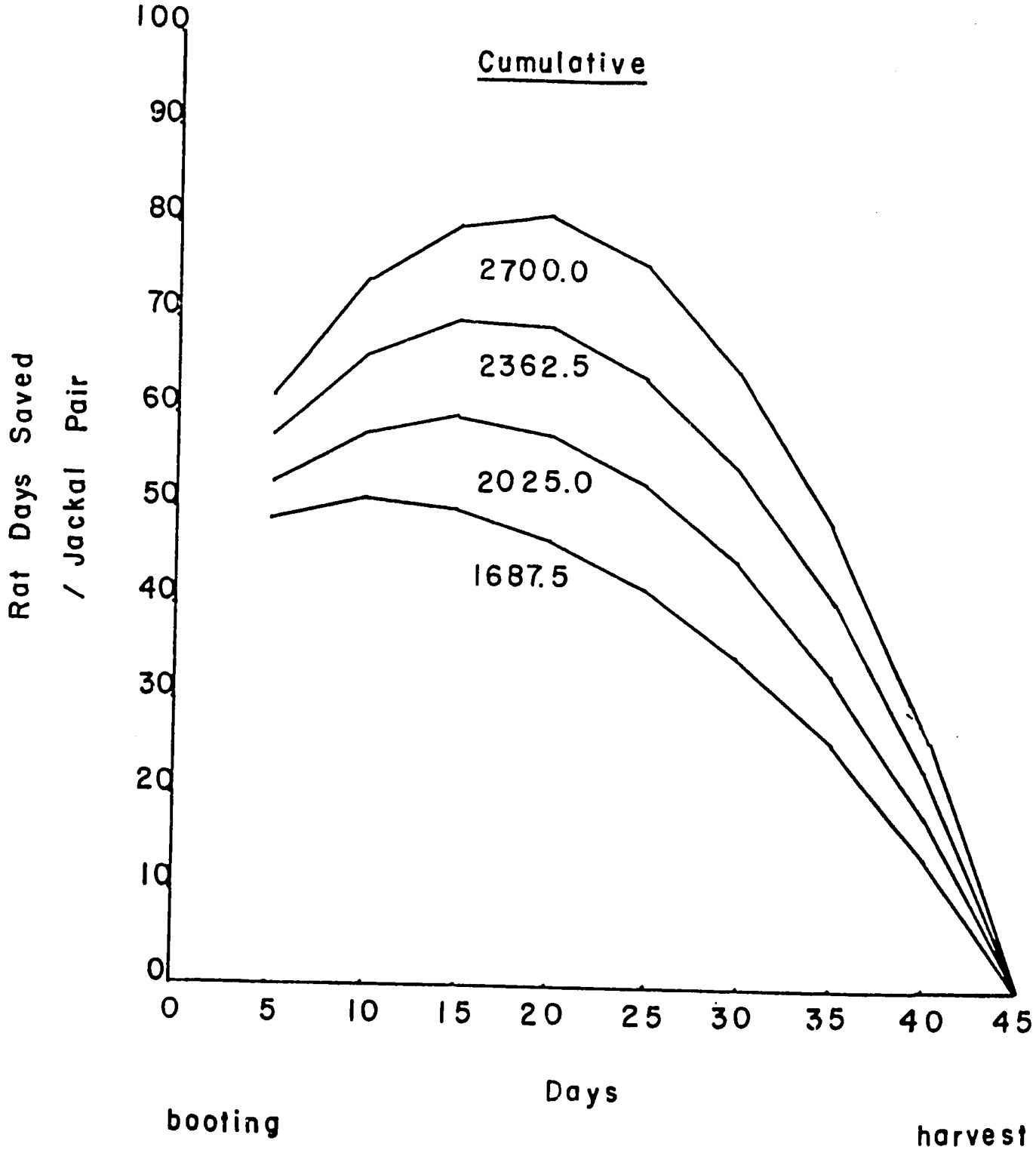

Species
Rattus rattus
Rattus norvegicus
Bandicota bengalensis
Bandicota indica
Nesokia indica
Mus. spp.
unidentified rat
Ishurdi (n = 539)
Mirzapur (n = 118)
0
10
20
30
40
50
% Rodents Found in Scats

Fig. 5


Percent Scats with Remains of
Burrowing Rats
Rattus rattus
Mus spp.
50
40
30
20
10
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
(212)
(89)
(107)
(198)
N





Period of Rat Damage to Wheat

Bangladesh Technical Reports

Technical Report No. 1. Rodent damage to wheat in Bangladesh. Vertebrate Pest Division, BARI, 1979.

Technical Report No. 2. Yield reduction in rice by simulated rat damage. Vertebrate Pest Division, BARI, October 1979.

Technical Report No. 3. Studies with zinc phosphide on *Bandicota bengalensis* and *Rattus rattus* in Bangladesh. Vertebrate Pest Division, BARI, January 1980.

Technical Report No. 4. Field trial using four rodenticides in deepwater rice. Vertebrate Pest Division, BARI, February 1980.

Technical Report No. 5. Bird damage control in Bangladesh sprouting wheat. Vertebrate Pest Division, BARI, April 1980.

Technical Report No. 6. Comparison of two methods for monitoring population indices of small mammals in Bangladesh deepwater rice. Vertebrate Pest Division, BARI, April 1980.

Technical Report No. 7. A comparison of three methods to determine food preferences in the lesser bandicoot rat (*Bandicota bengalensis* GRAY). Vertebrate Pest Division, BARI, June 1980.

Technical Report No. 8. Rodent movements in wheat fields. Vertebrate Pest Division, BARI, July 1980.

Technical Report No. 9. Yield reduction in wheat by simulated and actual rat damage. Vertebrate Pest Division, BARI, July 1980.

Technical Report No. 10. Rodent control in wheat fields. Vertebrate Pest Division, BARI, August 1980.

Technical Report No. 11. A preliminary report on rodent ecology in deepwater rice, Vertebrate Pest Division, November 1980.

Technical Report No. 12. Demonstration of rodent control in wheat in Gazaria Thana, Bangladesh. Vertebrate Pest Section, BARI, July 1981.

Bangladesh Technical Reports

Technical Report No. 13. Comparative toxicity of several anticoagulant rodenticides to Bandicota bengalensis. Vertebrate Pest Section, BARI, December 1981.

Technical Report No. 14. Comparative trials of two rodenticides in small farm housing clusters. Vertebrate Pest Section, BARI, January 1982.

Technical Report No. 15. Control of pest bird damage to sprouting wheat. Vertebrate Pest Section, BARI, February 1982.

Technical Report No. 16. Rat damage to the 1982 wheat crop in Bangladesh. Vertebrate Pest Section, BARI, May 1982.

Technical Report No. 17. A comparative trial of two rodenticides in Bangladesh wheat fields. Vertebrate Pest Section, BARI, May 1982.

Technical Report No. 18. Laboratory and field evaluation of 4-aminopyridine (Avitrol) as a bird repellent in Bangladesh. Vertebrate Pest Section, BARI, May 1983.

Technical Report No. 19. Rodent control on island/villages in deepwater rice in Bangladesh. Vertebrate Pest Section, BARI, May 1983.

Technical Report No. 20. Preliminary laboratory evaluation of bromethalin as a rodenticide against Bandicota bengalensis. Vertebrate Pest Section, BARI, November 1983.

Technical Report No. 21. Rat damage characteristics and assessment methods in deepwater rice. Vertebrate Pest Section, BARI, December 1983.

Technical Report No. 22. Repellency and toxicity of bird control chemicals to Bangladesh pest birds. Vertebrate Pest Section, BARI, May 1983.

Technical Report No. 23. Simulated bird damage on sprouting what to estimate the yield loss. Vertebrate Pest Section, BARI, August 1983.

Technical Report No. 24. Jackal and rat damage assessment in sugarcane in the Sripur area, Bangladesh. Vertebrate Pest Section, BARI, November 1984.

Technical Report No. 25. Post-harvest stored food losses at farm and village level: small mammal species composition and population estimates. Vertebrate Pest Section, BARI, September 1984.

Technical Report No. 26. Effect of simulated rat damage on deepwater rice in Bangladesh. Vertebrate Pest Section, BARI, December 1984.

Technical Report No. 27. The agricultural and economic importance of the jackal (Canis aureus) in Bangladesh. Vertebrate Pest Section, BARI, December 1984.

Technical Report No. 28. Reflective ribbon as a bird repellent in maturing grain and oilseed crops in Bangladesh. Vertebrate Pest Section, BARI, March 1985.

Technical Report No. 29. A preliminary research bibliography for the jackal (Canis aureus) in Bangladesh. Vertebrate Pest Section, BARI, April 1985.

Technical Report No. 30. Wheat yield reduction by simulated bird damage at sprouting stage. Vertebrate Pest Section, BARI, April 1985.

Technical Report No. 31. Tiller cutting behavior of Bandicota bengalensis at different growth stages of wheat. Vertebrate Pest Section, BARI, June 1985.

Technical Report No. 32. Immobilization of golden jackals in Bangladesh with ketamine. Vertebrate Pest Section, BARI, July 1985.

Technical Report No. 33. Postharvest losses in farm houses in Bangladesh: rodent population estimates and potential food grain losses. Vertebrate Pest Section, BARI, July 1985.

APPENDIX 9.0

Project Scientists

Dr. Mohammed Abdul Karim, Chief Scientific Officer, Entomology Division, Ph.D., Bowling Green State University, Bowling Green, Ohio. 1983. Effects of zinc phosphide treatments on Hawaiian sugarcane rat populations. Unpublished Ph.D. Thesis. 186 pp.

Dr. Parvin Sultana, Senior Scientific Officer, Ph.D., Colorado State University, Fort Collins, Colorado. 1985. Factors affecting the performance of bird control chemicals. Unpublished Ph.D. Thesis. 134 pp.

Mr. Mohammed Yousuf Mian, Senior Scientific Officer, M.S. in Zoology, University of Philippines, Los Baños. 1982. Ecology and control of sympatric rodents on islands adjacent to deepwater rice in Bangladesh. Unpublished M.S. Thesis. 111 pp.

Currently enrolled in Ph.D. program in Wildlife Biology at Colorado State University, Fort Collins, Colorado, with training emphasis on statistics, computer use, and modeling in grain storage facilities.

Mr. Mohammed Emdadul Haque, Senior Scientific Officer, M.Sc. in Zoology, University of Philippines, Los Baños. 1982. Yield reduction in wheat by simulated rat damage. Unpublished M.S. Thesis. 49 pp.

Completing Ph.D. program in Zoology at Dhaka University, Bangladesh. His research topic is "The biology, agricultural importance, and control of the short-tailed mole rat, *Nesokia indica*, in Bangladesh."

Mr. Rajat K. Pandit, Scientific Officer, M.Sc. in Zoology, University of Philippines, Los Baños. 1988. Rodenticidal properties of crude extracts of *Manihot esculenta* Crantz, *Dioscorea hispida* Dennsts., and Thevetia peruviana (Pers.) Merr.

United States Department of Agriculture
Animal and Plant Health Inspection Service
Science and Technology
Denver Wildlife Research Center
Building 16, P.O. Box 25266
Denver Federal Center
Denver, CO 80225-0266

BJECT: Zinc Phosphide Technical Assay

DATE: May 22, 1989

TO: Richard Bruggers
Section Chief
International Programs Section

Analytical Chemistry Section Method 11A was used to assay 103 samples of technical grade zinc phosphide. One hundred and ten samples were received on April 28, 1989. Seven of the samples were unidentifiable (89-027-89 through 89-027-95) and were not assayed. The physical properties of the technical material varied between samples. Differences in color, density, solubility, and texture were observed.

Note that Method 11A is not validated for samples containing less than 50% zinc phosphide. Values below 50% purity were estimated by assuming a linear detector response, and calculating percent zinc phosphide as stipulated in the method.

No chromatographic responses were observed for samples 89-027-7 through 89-027-11, 89-027-21, 89-027-71 through 89-027-75, 89-027-81 through 89-027-88, and 89-027-96 through 89-027-100. The limit of detection has not been determined for this analytical method.

The results are reported on the following pages. The laboratory reference standard was from H.R. Harkins, Inc. (received 12/05/88, opened 01/30/89, purity = 99%) and was certified in our laboratory using a zinc phosphide primary reference standard from the EPA. The sample data are not corrected for the purity of the laboratory reference standard.

Please contact me at 776-7842 if I can be of further assistance.

John J. Lennon
Physical Science Technician

Carol
Carol Furcolow
Project Leader (Acting)

Analytical Services Project
Analytical Chemistry Section

c: J. Lennon
C. Furcolow
Chron

QA #: none
Invoice #: 89-027
Analyst: John J. Lennon
Notebook Reference: JL2: pages 66 through 79
Date of Analysis: May 9, 1989 to May 19, 1989

APHIS—Protecting American Agriculture

Zinc Phosphide Technical Assay

Samples within validated range

Sample	Cross-reference No.	Observed Purity	
89-027-1	D-AL-1	46%	Al-Amin Rat Killer
89-027-2	D-AL-2	59%	
89-027-3	D-AL-3	56%	Al-Amin Co.
89-027-4	D-AL-4	55%	
89-027-5	D-AL-5	59%	
89-027-46	D-FN-1	61%	Fancy Rat Killer
89-027-47	D-FN-2	54%	
89-027-48	D-FN-3	61%	Fancy Cosmetics
89-027-49	D-FN-4	61%	
89-027-50	D-FN-5	64%	
89-027-51	D-EY-1	76%	New Rattom Rat's Killer
89-027-52	D-EY-2	78%	
89-027-53	D-EY-3	79%	Eyad Chemical
89-027-54	D-EY-4	76%	
89-027-55	D-EY-5	81%	
89-027-56	C-S-1	88%	Special Sonia 9 Rat Killer Poison
89-027-57	C-S-2	96%	
89-027-58	C-S-3	88%	AL. Chemical + Co.
89-027-59	C-S-4	92%	
89-027-60	C-S-5	92%	
89-027-101	CK1-1	48%	Rat Finis
89-027-102	CK1-2	50%	
89-027-103	CK1-3	49%	Khaja Chemical Ind
89-027-104	CK1-4	48%	
89-027-105	CK1-5	53%	

The precision of the observed value is ± 3% of the observed value based on method validation data. Only one sub-sample was assayed from each sample submitted.

Invoice #: 89-027
Notebook Reference: JL2: pages 66 through 79
Laboratory Reference Standard: Zinc Phosphide from H.R. Harkins, Inc., received 12/05/88 (opened 01/30/89)

166

Zinc Phosphide Technical Assay (Continued)

Samples Below Validated Range

Sample	Cross-reference No.	Estimated Purity	
89-027-6	D-AR-1	15%	RATTOM RAT KILLING Powder, ARIF
89-027-12	D-F-2	14%	RATTOM RAT KILLING POWDER
89-027-13	D-F-3	16%	FIROZ CO.
89-027-14	D-F-4	13%	
89-027-15	D-F-5	15%	
89-027-16	D-M-1	15%	META'S RAT KILLER
89-027-17	D-M-2	13%	META ENTERPRISE
89-027-18	D-M-3	14%	
89-027-19	D-M-4	14%	
89-027-20	D-M-5	14%	
89-027-22	D-J-2	2%	HARUN'S RAT KILLER
89-027-23	D-J-3	2%	JAHAN GIR CHEMICAL WORK
89-027-24	D-J-4	2%	
89-027-25	D-J-5	1%	
89-027-26	D-S-1	5%	SHUKAT'S SPEC. RAT KILLER, QU
89-027-27	D-FR-1	16%	FIROZ RATTOM
89-027-28	D-FR-2	13%	FIROZ CO.
89-027-29	D-FR-3	14%	
89-027-30	D-FR-4	12%	
89-027-31	D-FR-5	14%	
89-027-32	D-MS-1	11%	M. STAR RAT KILLER
89-027-33	D-MS-2	11%	MOONSTAR CHEM. CO.
89-027-34	D-MS-3	12%	
89-027-35	D-MS-4	15%	
89-027-36	D-MS-5	13%	
89-027-37	M-MR-1	3%	MERAR'S RAT KILLER
89-027-38	M-MR-2	3%	MERAR'S CHEMICALS
89-027-39	M-MR-3	3%	
89-027-40	M-MR-4	3%	
89-027-41	M-MR-5	3%	

The precision of the observed value is unknown. Only one sub-sample was assayed from each sample submitted.

Invoice: 89-027
Notebook Reference: JL2: pages 66 through 79
Laboratory Reference Standard: Zinc phosphide from H.R. Harkins, Inc., received 12/05/88 and opened 01/30/89

Zinc Phosphide Technical Assay (Continued)

Samples Below Validated Range (Continued)

Sample	Cross-reference No.	Estimated Purity	
89-027-42	D-S-2	5%	SAUKAT'S SPECIAL RAT KILLER
89-027-43	D-S-3	4%	QUADIR + CO
89-027-44	D-S-4	5%	
89-027-45	D-S-5	5%	
89-027-61	C-H-1	26%	H.D.S. SPECIAL RAT KILLER POIS
89-027-62	C-H-2	29%	HASAN CHEMICAL COL
89-027-63	C-H-3	27%	
89-027-64	C-H-4	30%	
89-027-65	C-H-5	27%	
89-027-66	C-R-1	7%	NEW RATTOM BISHTOP
89-027-67	C-R-2	7%	RAZZAK CHEMICAL CO.
89-027-68	C-R-3	7%	
89-027-69	C-R-4	7%	
89-027-70	C-R-5	7%	
89-027-76	C-SA-1	24%	SPECIAL RATOM
89-027-77	C-SA-2	42%	SALINA CHEMICAL CO.
89-027-78	C-SA-3	42%	
89-027-79	C-SA-4	33%	
89-027-80	C-SA-5	22%	
89-027-106	CK2-1	12%	~~KA~~ SPECIAL RAT FINIS
89-027-107	CK2-2	41%	KHJA CHEMICAL IND
89-027-108	CK2-3	44%	
89-027-109	CK2-4	42%	
89-027-110	CK2-5	39%	

The precision of the observed value is unknown. Only one sub-sample was assayed from each sample submitted.

Invoice: 89-027
Notebook Reference: JL2: pages 66 through 79
Laboratory Reference Standard: Zinc phosphide from H.R. Harkins, Inc., received 12/05/88 and opened 01/30/89.

48

APPENDIX 11.0

BARC WORKSHOP ON THE STATUS OF VERTEBRATE PEST RESEARCH IN BANGLADESH

A workshop to review the status of vertebrate pest research in Bangladesh was convened by BARC on 28 March, 1989 under the co-chairmanship of Dr. M.M. Rahman, Executive Vice Chairman of BARC, and Dr. A. Rahman, Member Director of Crops, BARC. The 48 participants included representatives of BADC, BARI, BAU, BRRI, DAE, Chittagong University, Dhaka University, Jahangirnagar University, Rajshahi University and USAID.

In introductory remarks, Dr. M.M. Rahman noted that the Bangladeshi farmer has yet to benefit from the ten years of technical assistance to BARI by the USAID/DWRC vertebrate pest project, from the GTZ vertebrate pest project with DAE, or from research at BRRI and the various universities. He concluded that a major reason for this was lack of effective communication and coordination among these organizations. The objective of this workshop was to re-establish communication by clarifying the issues and establishing a coordinating committee to recommend research priorities and the institution most appropriate to implement each. The following is a summary of the main findings presented in this workshop.

(1) The principal vertebrate pest problem in Bangladesh is preharvest rat damage to rice and wheat; this totals an estimated 1 to 3 percent of the expected annual yield or from 150,000 to 450,000 mT. Postharvest rodent damage adds

roughly 50,000 to 100,000 mT per annum. The destruction of poultry and livestock by predators, mainly jackals, and bird damage to sprouting wheat are also widespread.

(2) The principal rodent pest is the Lesser Bandicoot Rat (Bandicota bengalensis) It lives in underground burrow systems in which it stores panicles of rice and wheat.

(3) Zinc phosphide baits can be a very cost-effective means of killing bandicoot rats provided that the active ingredient is present in the recommended concentration and dosage and when the baits are inserted into recently excavated burrow openings. Baits may become less acceptable to the rats, however, when ripening panicles become available in the fields. A promising alternative is burrow fumigation with aluminum phosphide tablets, which are widely available and easy to use. The disadvantage of phosphine gas is it is potentially hazardous to the user and must be stored and applied with care.

(4) Long-term reduction of bandicoot populations is impractical and undesirable. Annual control campaigns which focus on reducing losses at times when damage will be greatest are a more practical and environmentally sound solution. Cost-effective annual control requires selective action when and where short-term population reduction of rats will achieve the greatest crop savings.

(5) Recent findings show that for most of Bangladesh control is the most cost-effective when done in September or October when the bandicoot rat population begins increasing to its annual peak, coincident with the aman rice harvest. Thorough control of burrow systems at this time will substantially reduce both

RECOMMENDATIONS

1. TIME OF APPLICATION OF RODENT CONTROL MEASURES:

From the study of population dynamics of rats it appears that rat population attains its peak during Nov.-Dec period. Another peak appears during May-June period. These two peaks syncronise with the maturity periods of Aman and Boro Crops. In the wheat growing areas a peak population also occurs during Feb.-March period which syncronises with maturing time of wheat. The highest peak however occurs during November-December period.

Maximum control effort should threrfore be taken prior to these peak population periods particularly prior to the occurrence of populati during Nov.-December. This may reduce the rat population to a great exte

2. ROLE OF JACKAL IN CONTROLLING RODENTS

Jackal is known to be a pest of many crops like sugarcane, melon and other fruit crops and also of domestic animals. At the same time jac is an important peredator of rodents and controls naturally the rodent p So, jackal in one hand is beneficial and harmful on the other. Much care to be taken in killing jackal to protect crops and domestic animals. A comprehensive study should be undertaken to quantify the importance of jackal as pest and predator of rodents and then to decide the control strategy of jackals.

3. INTEGRATION OF RESEARCH ACTIVITIES

It appears that in BARI some definite research project on vertebr pest management is in progress. Other organizations are engaged in carryi out work on the subject in piece meal. Effors should be taken to integrat the research work of different organizations particularly of the universi to utilize properly the available expertise and to initiate a coordinate

pre- and post-harvest rat damage to aman rice and provide a carryover effect for the subsequent wheat and rice crops.

(6) Research findings show that rats are the major component of the diet of jackals and that predation is likely to be an important determinant of bandicoot numbers and annual pattern of fluctuation. Rodents likely provide a preybase for a wide variety of predators in Bangladesh, and the potential for poisoning non-target wildlife with rodenticides needs to be examined. By the nature of their population dynamics, predators are more easily eliminated than are rats. Where this occurs, rat populations and the damage they cause can substantially increase. The importance of predators as a means of biological rat control in Bangladesh needs further examination.

(7) Control methods for reducing pre-harvest rat damage and a strategy for their most cost-effective use under the ecological conditions in Bangladesh are now available for transfer to farmers. The next step is testing farmer acceptance of this technology when presented by the DAE.

APPENDIX 12.0

List of Persons Interviewed

USAID	Dr. Ray H. Morton, Project Director
	Mr. Allen Hankins, Consultant
	Mr. Latifur Rahman, Assistant to Agricultural Project Officer
BARC	Dr. M. M. Rahman, Executive Vice-Chairman
	Dr. M. Ayubur Rahman, Member-Director(Crops)
	Dr. M. H. Khan, C.S.O. and Coordinator, FSR
	Dr. Robert E. Witters, ISNAR Representative
	Dr. Bruce Currey, Human Resource Development Program Specialist, Winrock International
BARI	Dr. M. H. Mondal, Director General
	Dr. Mohammed Ameerul Islam, Director (Research)
	Dr. Zainul Abedin, Head, OFRD
	Dr. M. A. Karim, Head, Entomology Division and In-charge VPS
	Dr. Parvin Sultana, S.S.O., VPS
	Dr. Michael M. Jaegar, DWRC Project Leader
BRRI	Dr. Shamsul Alam, Director (Administration)
	Mr. M. A. Razzaque, S.S.O., Entomology Division
DAE	Mr. A.K.M.A. Kibria, Director, Field Services

DAE/PLANT PROTECTION WING:

Mr. M. Huq, Director

Mr. Syed Majed Ali, Deputy Director (Operation)

Mr. Kazi Tofazzal Hossain, Deputy Director (Surveillance and Forecasting)

Mr. Mohiuddin Ahmed, Senior Chemist

Mr. Delwar Hossain, Senior Instructor

Mr. Santosh K. Sarker, Senior Instructor

Checchi & Company Consulting, Inc.

Mr. Carl R. Fritz, Team Leader/Human Resources Development Specialist

Dr. Ali Mohammad, Deputy Team Leader/Agricultural Economist

Dr. E. D. Magallona, Integrated Pest Management Specialist

Dr. R. N. Mallick, Farming Systems Research Specialist

Food Department

Mr. Mohammed Nurul Islam, Director General

Mr. A. H. Mohammed Shamsul Alam, Director, Supply, Distribution and Marketing

Mr. Nurul Afsar, Director, Inspection, Development & Technical Services (IDTS)

Mr. Kazi Mahbubur Rahman, Additional Director, IDTS

Agrani Traders (Pesticide Importers):

Mr. Mallik Sirajul Islam, Manager (Sales)

Beximco Agrochemicals Ltd.:

Mr. Habibur Rahman, Manager, Product & Agency Affairs

Imperial Chemical Industries (ICI):

Dr. Gareth Capel Williams, Insecticides Manager, England

Mr. Bruce Pointer, Business Manager (SW Asia), England

Mr. Q. G. Mainuddin

FAO

John A. Hoskins, Representative for Bangladesh