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SCIENCE AND TECHNOLOGY

DENVER WILDLIFE RESEARCH CENTER

ANNUAL REPORT

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Animal and Plant Health Inspection Service
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DENVER WILDLIFE RESEARCH CENTER
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THE DENVER WILDLIFE RESEARCH CENTER

PROTECTING AMERICA'S AGRICULTURE from vertebrate pests is the challenge of the U.S. Department of Agriculture's (USDA) Animal Damage Control (ADC) Program. The Denver Wildlife Research Center (DWRC) is an Animal and Plant Health Inspection Service (APHIS), Science and Technology (S&T), research institution charged with providing objective scientific information for the development of methods and materials for vertebrate damage control. The DWRC provides the ADC Program and the public with the knowledge and tools to reduce wildlife conflicts with agriculture and other human endeavors, and transfers existing technology to broader uses in animal damage control. Activities include development and testing of damage control techniques involving chemical, physical, biological, or cultural approaches for minimizing or eliminating economic damage and safety-related hazards, and laboratory and field studies of damaging species and their habitats to discover new approaches to damage control.

Studies are oriented to ensure that methods developed and used for alleviating animal damage are biologically sound, effective, safe, economical, and acceptable within the broad public interest. Projects are designed to produce methods, technology, and materials for reducing animal damage and to ensure the availability of information and expertise to the agricultural community and public through the ADC Program and other USDA outlets. This is accomplished through the publication of results and technology transfer activities involved in damage situations of the Center. Research is conducted on a wide array of wildlife species.

Providing objective scientific information for new, and maintenance of existing, ADC chemical registrations is a major task. Laboratory and field studies of animal behavior and ecology help to define habits of damaging species and individuals, and to develop ways to reduce hazards to other components of the ecosystem. Center chemists, statisticians, animal care technologists, and specialists in computers, electronics, and information transfer support the scientific program while creating advances in their specialties.

International vertebrate pest management activities of the Center are carried out in cooperation with the U.S. Agency for International Development and other international organizations. Developing and testing new techniques and transferring the control technology to scientists and operational personnel in host countries are major objectives. Center scientists at overseas field stations and at Denver develop methods for reducing severe agricultural damage caused by a variety of rodents, birds, and other vertebrate pests in Latin America, Africa, and Asia.

Studies conducted at the Denver Wildlife Research Center will continue to provide new information needed to protect American agriculture from wildlife-related problems and help manage our wildlife resources wisely and effectively into the future.

PROJECT TITLE: Research and Methods Development

PROJECT LEADER: Elizabeth A. Mishalanie (303) 236-7872

INTRODUCTION:

Analytical methods related to current and potential vertebrate pest control chemicals need to be developed and frequently updated to provide the necessary support for the Denver Wildlife Research Center (DWRC), the Animal Damage Control Program (ADC), Science and Technology (S&T) and the Animal Health Inspection Service (APHIS). For registration-related activities, the development of analytical methodology is needed to support the following: field efficacy trials; residue trials; laboratory feeding trials; quality control tests for baits and formulations; stability and longevity studies; soil, water, and vegetation accumulation and metabolism; animal metabolism; and the development of human health, application, and use restrictions. Other registration-related activities non-target involve and environmental fat studies such as hydrolysis and photodegradation, and wildlife toxicology studies such as LD50, LC50, and reproduction. These studies require the development of specific analytical methodology for each chemical and sample matrix of interest in accordance with Environmental Protection Agency (EPA) approved guidelines. Analytical methods are also needed to assist in the search for new chemicals for use in vertebrate pest control, for the identification of safe and reliable physiological and mechanical markers used in tracking and migratory studies, and in the assessment of the efficacy and selectivity of application techniques.

OBJECTIVES:

1. Develop analytical methods for the qualitative and quantitative determination of vertebrate pest control chemicals in various matrices.

2. Provide analytical chemistry support for chemical studies required for the development or maintenance of APHIS registrations.

3. Conduct or assist in conducting chemical studies required for the development or maintenance of APHIS registrations.

ACCOMPLISHMENTS:

The data requirements for analytical method validation and procedures for writing analytical methods were formalized in a Standard Operating Procedure (SOP) WRC-193 to meet EPA Good Laboratory Practice (GLP) standards.

New instruments were procured in an effort to meet DWRC, ADC, S&T and APHIS needs and the EPA GLP requirements. The Project hired one permanent and one temporary employee, resulting in a total of 4.6 FTE's by the end of FY89.

A working relationship is being investigated with the APHIS National Monitoring and Residue Analysis Laboratory (NMRAL) in Gulfport, MS. One DWRC strychnine method was transferred to NMRAL. The method was tested,

adapted for the NMRAL equipment and standard procedures, and method validation was initiated.

Chemical support and consultation was provided for the Monell, Bowling Green, Sandusky, and Olympia field stations. Technical assistance was provided to various individuals in the Washington State Department of Agriculture, the California State Department of Agriculture, the University of Idaho, Temple University (MB Laboratories), Bell Laboratories, Coffey Laboratories, EPA Beltsville Laboratories, the U.S. Fish and Wildlife Service Forensic Laboratory, H.R. Harkins, Inc., H. Interdonati, Inc., Oregon Rodent Control Outfitters (ORCO), and Signetics.

Ten new analytical methods were issued, and three existing methods were updated to account for formulation changes or to improve existing methodology. Copies of all methods were sent to the National Enforcement Investigations Center (NEIC) of the EPA, and were made available to the public through an NEIC newsletter. The following is a summary of accomplishments, categorized by chemical.

Compound 1080: A new analytical technique was developed for sodium monofluoroacetate (Compound 1080) based on ion chromatography (IC). Two methods were issued based on this technique; Compound 1080 technical assay (Method 13B), and the Livestock Protection Collar formulation assay (Method 21A). The development of a method for the determination of Compound 1080 on sheepskin and wool was initiated on IC.

A method for Compound 1080 grain bait assays was developed based on gas chromatography (GC) with mass selective detection (MSD) (Method 8A). This method was subsequently updated due to instrumental difficulties, and is currently based on GC with electron capture detection (ECD) (Method 8B).

The development of a method for the trace determination of Compound 1080 in various tissues was initiated using the GC/ECD technique.

Compound 1080 Single Dose Baits were assayed using both of the GC/MSD and GC/ECD techniques.

Strychnine Alkaloid: An analytical method was developed for a strychnine hydrolysis study (Method 18A) by High Performance Liquid Chromatology (HPLC). The hydrolysis study was conducted in our laboratory, and a report was sent to the EPA.

A HPLC assay method for five formulations of strychnine grain bait was developed (Method 24A). In addition to routine use in the Analytical Services Project, this method was used to check results obtained by two different analytical methods used in other laboratories (Washington State Department of Agriculture and Coffey Laboratories). Our results indicated severe biases in the other methods. Method 24A was also used to assay commercial strychnine baits for Oregon Rodent Control Outfitters (ORCO). The results compared favorably to results obtained by a different analytical method used at the University of Idaho on the same batches of bait, although the Idaho method was not as precise as Method 24A.

Two HPLC analytical methods (Methods 15A and 16A) were developed for three strychnine end-use products requiring one-year stability tests for registration. Research involved in generating the methods revealed inadequacies in the formulations of the two paste products and a corn bait used for pigeons. The Chemical Development/Registration Section (CD/RS) submitted samples of new formulations for these products, and an improvement was observed.

Method 23A was developed for the determination of strychnine in water by HPLC to support aquatic toxicity tests, and Method 26A was developed for strychnine in bird feed to support in a series of avian toxicity tests.

Research and Method Development Project studies were also initiated for the following; 1) the trace determination of strychnine in pocket gopher tissues by GC, 2) a HPLC method to support a soil photodegradation study to be conducted by the CD/RS, 3) a precise UV assay method for strychnine technical grade materials, and 4) a HPLC-GC/MSD method for the identification and quantification of trace impurities in technical grade strychnine alkaloid.

Zinc Phosphide: A new analytical technique was developed for zinc phosphide based on megabore GC with a filter photometric detector. This technique formed the basis for Method 11A, which is an assay method for technical grade zinc phosphide.

Fenthion: Fenthion levels were determined in hundreds of samples submitted by the International Programs Research Section. Due to a lack of control samples and uncertainties in the field preparation of many of the samples, a standard analytical method could not be validated and used for this project. Concentration data were generated for the spray formulation, filter papers, residues on vegetation and birds, and residues in water, and in bird crop contents. Fenthion could not be determined in some samples, such as insects and bird tissues, due to severe interferences from other constituents in the sample extracts.

Sodium Cyanide: The use of a cyanide selective electrode was investigated for the development of an assay method for sodium cyanide in M-44 cartridges. Initial results were encouraging, but the project was put on hold due to registration priorities with other pesticides.

DRC-1339: Development efforts were initiated for a 3-chloro-4-methyl benzenamine HCl (DRC-1339, Starlicide) bait assay using HPLC. The project was put on hold due to priorities with other pesticides.

CPT (DRC-1347): The CPT concentrate and spray formulation assay method by HPLC was updated (Method 1B) because of a change in the spray formulation.

A commercially-available air monitor was adapted for use as a selective detector for CPT in air. The air monitor was tested in our laboratory, and an operational manual was written for field personnel.

A project was initiated to develop an HPLC analytical method for quantitating CPT and fluorescein dye on TLC plates from roost spray applications.

DMA and MA: A project was initiated to develop analytical methodology for determining the concentration of dimethyl anthranilate (DMA) and methyl anthranilate (MA) on vegetation. An HPLC technique was developed for both DMA and MA. Difficulties were encountered in extracting MA from encapsulated products, but the project was put on hold due to priorities with other pesticides.

TRAINING:

Various staff members attended training courses pertaining to the use of computers, the operation of new analytical instruments, maintenance of instruments, quality assurance/quality control principles, radiation safety, supervisory skills, personnel management skills, project management, and statistics. Three conferences were attended- the Pittsburgh Conference and Exposition, the 31st Rocky Mountain Conference, and the Ninth Great Plains Wildlife Damage Control Workshop. Seminars were attended regarding current GLP standards regulations, proposed GLP standards regulations, FIFRA inspection authority, stress management, and leadership skills for women.

REPORTS:

Fifteen Research and Methods Development Project reports were issued. One study protocol and one final report regarding the strychnine hydrolysis study was sent to the EPA.

PRESENTATIONS:

Mishalanie, E. A. and E. Schafer. 1989. Analytical Chemistry in the Animal Damage Control Program. Ninth Great Plains Wildlife Damage Control Workshop. April 19, 1989.

PUBLICATIONS:

Linz, G. M., D. F. Mott, and E. W. Schafer, Jr. 1988. Progress on the Development of an Avian Toxicant (CPT). Proc. Sunflower Res. Workshop. Bismarck, N.D. January 25, 1988. pp. 3-4.

PROJECT TITLE: Analytical Services

PROJECT LEADER: Carol A. Furcolow (Acting) (303) 236-7842

INTRODUCTION:

The services provided by the Analytical Services Project (ASP) support the research and registration-related activities of the Denver Wildlife Research Center (DWRC), the Animal Damage Control Program (ADC), Science and Technology (S&T), and the Animal and Plant Health Inspection Service (APHIS). Rigorously tested and validated analytical methods are used to analyze samples from chemical registration-related activities such as the following: field efficacy trials; residue trials; laboratory feeding trials; quality control tests for baits and formulations; stability and longevity studies; soil, water, and vegetation accumulation and metabolism; animal metabolism; and the development of human health, application, and use restrictions. Analytical Services also supports studies involving new chemicals for use in vertebrate pest control, the identification and testing of new physiological and mechanical markers used in tracking and migratory studies, quality control for the Pocatello Supply Depot (PSD) and in the assessment of efficacy and selectivity of application techniques.

OBJECTIVES:

1. Conduct analytical determinations of APHIS chemicals in technical grade materials, baits, formulations, environmental samples, and tissue samples using section-validated analytical methods.

2. Conduct or assist in conducting studies required for APHIS chemical registration or re-registration using section-validated analytical methods.

3. Provide quality control monitoring for Pocatello Supply Depot.

4. Provide analytical services to APHIS personnel in the identification of pesticides related to suspected field mortalities.

ACCOMPLISHMENTS:

The quality assurance/quality control (QA/QC) program was improved, and thirty-eight Standard Operating Procedures (SOP's) were completed and issued for the Analytical Chemistry Section (ACS).

New instruments were procured in an effort to meet DWRC, ADC, S&T, and APHIS needs and the Environmental Protection Agency (EPA) Good Laboratory Practice (GLP) requirements. Supplies for these instruments and various sample preparation devices were also purchased. Three employees (two permanent, one temporary) were hired, resulting in a staff of 5 FTE's by the end of FY 89.

The Project began assessing the quality of strychnine grain baits formulated the PSD in conjunction with the Chemical Development/ Registration Section.

The major facility renovation was initiated to meet OSHA (Occupational Safety and Health Administration) and GLP requirements, and the laboratory and staff was preparing to relocate at the end of FY 89.

Analytical chemistry support was provided for DWRC and ADC research and registration efforts using analytical methods developed and validated by the Research and Methods Development Project. These projects included; 1) Compound 1080 technical and grain bait assays, 2) strychnine alkaloid technical, paste formulation, water formulation (for aquatic toxicity tests), and grain bait assays, 3) CPT technical and spray formulation assays, 4) diphacinone bait assays and residue determinations in tissues, and 5) zinc phosphide assays. A 30-day strychnine hydrolysis study was completed. The following is a summary of the samples processed through the ASP:

I. Assays

A) Technical grade samples: (7 replicates of each sample submitted)

Strychnine alkaloid	5
CPT	7
Compound 1080	14
Zinc phosphide	176
TOTAL	202

B) Baits: (3 replicates of each sample submitted)

Strychnine alkaloid	180
Diphacinone	4
Compound 1080	24
TOTAL	208

C) Other Formulations: (3 replicates of each sample submitted)

Strychnine alkaloid pastes	2
CPT	2
TOTAL	4
TOTAL ASSAYS:	414

II. Single Residue Determinations (5 tissue matrices)

Diphacinone	145

III. Environmental Fate Studies (3 replicates of each sample submitted)

Aquatic Toxicity Test Samples

Strychnine/Water 44

TOTAL OF ALL SAMPLES PROCESSED BY ANALYTICAL SERVICES: 603

TOTAL REPLICATE SAMPLES PROCESSED BY ANALYTICAL SERVICES: 2,327

TRAINING:

Various staff members attended training courses pertaining to the use of computers, the operation of new analytical instruments, maintenance of instruments, laboratory safety and health, hazardous waste management, and principles of writing techniques. Two conferences were attended-the 31st Rocky Mountain Conference and the Ninth Great Plains Wildlife Damage Control Workshop. Seminars were attended regarding current GLP standards regulations, proposed GLP standards regulations, FIFRA inspection authority, and stress management.

REPORTS:

Sixty-five ASP reports were issued during FY-89 to clients/cooperators.

PRESENTATIONS:

None

PUBLICATIONS:

None

PROJECT TITLE: Denver Field Project

PROJECT LEADER: George M. Linz, 303-236-4405, 10/88 - 3/89
John L. Cummings (Acting), 303-236-7877, 4/89 - 9/89

INTRODUCTION:

In addition to the responsibilities described below, this Project also had lead responsibility for developing control methods for reducing blackbird damage to sunflower in the Dakotas. In April 1989, this responsibility was reassigned to the newly established North Dakota Field Station. Research accomplishments in sunflower during FY89 are presented in the report for the North Dakota Project.

The primary emphasis of this project is to develop methodology to reduce agricultural, safety and nuisance problems caused by birds in the western and midwestern U.S. These problems include damage to sprouting grains and nuisance problems caused by resident and migrating populations of Canada geese, and predation on newborn livestock by ravens.

Canada goose populations have been increasing in many areas of the United States resulting in increased damage to sprouting and ripening crops, and nuisance problems in and near urban areas. A recent survey of ADC state supervisors documented that more than 4,000 complaints had been received by these offices in the last year. In urban areas, the problem is often associated with foraging on grass in landscaped areas, parks, backyards and on golf courses. In addition, droppings left by geese reduce the aesthetic value and recreational use of these areas and can be a health hazard. Management of these birds usually consists of attempts to reduce populations by trapping, translocation, nest and egg destruction, pyrotechnic devices, relaxing hunting regulations and sterilization. However, use of these techniques is often limited by costs, weather, time of year, or logistics. New bird damage control methods, and comprehensive, integrated pest management plans based on sound ecological principles, are needed to solve the problems caused by geese. Such concerns have stimulated efforts toward the development of a chemical repellent that would be safe to both target and nontarget species.

Crows and ravens are responsible for a variety of agricultural and ecological problems, including predation on newborn livestock, predation of nut crops and other agricultural commodities, and predation of eggs of endangered or sensitive avian and terrestrial species. Effective control strategies are needed for responsibly managing and reducing these problems. A part of this strategy will involve selective lethal control of individuals which can be accomplished with Section 3 registration of DRC-1339 for this use.

OBJECTIVES:

1. Evaluate the effectiveness of methyl anthranilate (MA) for reducing waterfowl depredation to grass and sprouting grains.

2. Expand existing DRC-1339 Federal registration to include use on depredating ravens and crows.

ACCOMPLISHMENTS DURING FY89:

A field test was conducted in New Jersey from June to October to evaluate dimethyl anthranilate (DMA) and methyl anthranilate (MA) as a Canada Goose repellent on grass. Five turf sites were treated with DMA and MA in June and July at a 3-lb/acre rate with ground spray equipment. Results showed that bird numbers were significantly reduced in DMA-treated areas but not in MA-treated areas. The accumulation of droppings was also less in treated areas than control areas, although the reduction was not significant ($p = .133$). Reduction in goose droppings by site during the 28-day treatment period ranged from 0 to 67% and 0 to 80% for DMA and MA, respectively. Chemical concentrations in formulated samples exposed to environmental conditions showed a 41% and 47% loss of chemical after 28 days for DMA and MA, respectively. When MA was evaluated independently during October and November, it was ineffective in reducing goose droppings and numbers. Material samples exposed to the environment showed an average chemical loss of 57% after 14 days. A Bird Section Research Report, No. 443, was completed under this step.

Methyl anthranilate encapsulated in a pressure release formulation was evaluated in a large fenced enclosure. Eight 40x40 ft. grass plots were established within the enclosure. Plots were paired and six Canada geese were allowed to feed on each paired plot during daylight hours. Bird observations and droppings were collected during a 6-day pre-treatment and 20-day post-treatment period. Preliminary results indicated that an application rate of 0.5 gal/acre only slightly reduced use of treated plots whereas 1.0 gal/acre rate significantly reduced use of treated plots. The level of protection on treated plots was reduced over time suggesting that the encapsulation formulation needs refinement to increase the longevity of the chemical. Data from this study are being compiled for inclusion into a Bird Section Research Report.

Trimethacarb, (Broot 15GX), a registered granular insecticide, was tested in the flight pen of the Florida Field Station to determine its potential to reduce grazing by American coots on rye grass. Grazing activity in treated portions of experiment plots was reduced an average of 47% 3 days post-treatment but only 14% after 5 days. Study details are contained in Bird Section Research Report No.445.

In August 1988, the ADC program submitted to EPA a revised label for DRC-1339 to include its original feedlot use and attempted to consolidate 13 of 14 24C labels for DRC-1339. On April 5, 1989, EPA responded that the labeling was unacceptable and required revision and also requested laboratory and field data to support the expanded uses. In May 1989, a decision was made to continue to pursue the revised label by attempting to revise the label further and to furnish EPA with all data that currently existed for DRC-1339. To accomplish this task, a working group was formed consisting of Ed Knittle, Chemical Development/Registration Section; Jim Glahn, Bird Section, and Doug Hall and Bill Bell of the ADC Eastern and Western Regions, respectively. This working group met twice in June 1989

and formulated label revisions and summarized existing data for DRC-1339. Just prior to the first meeting, the ADC program was advised by EPA that DRC-1339 was in the highest priority list (A list) for reregistration. Based on review of the existing data, the working group decided to pursue all revisions of the label consolidating all uses previously mentioned into four separate labels: blackbirds and starlings at feedlots; blackbirds, crows and starlings at staging areas; pigeons in structure roosts; and ravens, crows and magpies involved in livestock depredation.

With contract funding from the U.S. Navy, a field study was designed and conducted to collect ecological information on ravens that purportedly depredate eggs of endangered California least terns that utilize habitat within the Camp Pendelton Marine Base. Twenty-one ravens were captured and equipped with radio transmitters that provided information on the movements, home ranges and behaviors of ravens near White Beach, where the terns have not been successful in nesting. Telemetry data indicated that nesting ravens stay within a clearly defined territory. After the young have fledged, the territories begin to gradually break down. On the other hand, several non-nesting birds moved at least 15 km from their capture site. Data are currently being compiled and will be used to help formulate and design of a study designed to collect information on the efficacy and nontarget hazard using DRC-1339 treated eggs to control the local raven population. This study will be conducted contingent upon continued funding from the U.S. Navy.

REPORTS AND PUBLICATIONS:

Cummings, J.L., J.L. Guarino, and C.E. Knittle. 1989. Chronology of blackbird damage to sunflower. Wildl. Soc. Bull. 17:50-52.

Cummings, J.L. and E.W. Schafer, Jr. 1989. Evaluation of a DRC-1347 (CPT aerial spray application for reducing a roosting blackbird population. Proc. Sunflower Res. Workshop, Fargo, ND. Page 26.

Cummings, J.L. 1989. Ecology of blackbirds in the West, including 1988 banding and recovery data collected in 1987. Denver Wildlife Research Center, Bird Section Research Report No. 436. 6 pp.

Cummings, J.L., J.R. Mason, D.L. Otis and J.F. Heisterberg. 1989. Evaluation of dimethyl anthranilate and methyl anthranilate as a Canada goose repellent on grass. Denver Wildlife Research Center. Bird Section Research Report No. 443. 21 pp.

Knittle, C.E., J.L. Cummings, G.M. Linz, and J.F. Besser. 1988. An evaluation of modified 4-amino pyridine baits for protecting sunflower from blackbird damage. Proc. Vertebr. Pest Cont. 13: 248-253.

Linz, G.M., J.L. Cummings, J.E. Davis, Jr., C.E. Knittle, and J.J. Hanzel. 1989. 1987 sunflower crop in Benson and Ramsey counties, ND: yield, oil content and blackbird damage. Proc. Sunflower Res. Workshop, Fargo, N.D. Page 25.

Linz, G.M., M.L. Avery, J.F. Besser, J.B. Bourassa, J.L. Cummings, J.E. Davis, Jr., R.A. Dolbeer, R.M. Engeman, C.E. Knittle, D.F. Mott, D.L. Otis, and E.W. Schafer, Jr. 1989. Treatment of two blackbird roosts in North Dakota with simulated CPT-Avicide formulation. BSRR No. 435. 70 pp.

Stickley, A.R., Jr., J.L. Cummings, J.F. Heisterberg, and P.W. Lefebvre. 1988. Field trial of a water cannon using DRC 6749 for reducing blackbird populations in North Dakota. BSRR No. 419. 10 pp.

PROJECT TITLE: Denver Physiology Project

PROJECT LEADER: R. Daniel Thompson, 303-236-7870

INTRODUCTION:

Physiological and behavioral research is needed to help provide new and/or improved methodology to solve problems of economic loss to agriculture and threats to humans caused by vertebrate pests. This project provides the capability to examine the behavioral and physiological characteristics of pest species that can be exploited for developing novel or new control methods. The emphasis is on development of new management techniques and improvement of existing methodology to meet changing field needs.

OBJECTIVES:

1. Develop efficient and accurate methods to predict mortality of avian pests treated with the avicide 3-chloro-4-methylbenzenamine(CPT).

2. Conduct physiological research to facilitate design of the most effective and environmentally acceptable use of CPT as an avian toxicant.

3. Evaluate the efficacy of alternative chemicals as bird roost toxicants.

4. Evaluate the plume characteristics of fog oil smoke as a delivery system for an avicide intended for use on roosting birds.

ACCOMPLISHMENTS DURING FY89:

Research findings from the pilot protocol entitled "Blood Chemistry Response of Starlings (Sturnus vulgaris) to Oral Dosage of 3-Chloro-4-Methylbenzenamine (CPT)" revealed that oral dosage of starlings with 10 mg/kg of CPT increased mean blood uric acid more than 700 percent and decreased mean thyroxine (T3 and T4) level more than 85 percent in 8 hours. The results suggest that sampling and testing of micro quantities of blood for uric acid and/or other components soon after treating bird roosts with CPT may provide a fast, reliable, and cost effective method to predict lethality of CPT roost sprays. If so, it would obviate the present requirement to capture and hold and/or radio track birds from treated roosts to evaluate efficacy of CPT sprays.

Blood samples were collected from birds exposed to the CPT field test in Mississippi. Analysis of the samples verified significantly elevated levels of uric acid in treated birds. A follow-up study protocol was prepared for further refining the methodology and prediction model.

Oak Ridge National Laboratory was retained in September 1989 under an Interagency Agreement to equip an inhalation chamber system at DWRC with a nebulizer to aerosolize CPT (free base and hydrochloride) in such a way that particle size and concentration can be varied and measured in inhalation toxicity studies. An important objective of this Project in FY90 will be to use this system to define the importance of inhalation as a

mode of action for CPT, and use this information to guide development of safer and more efficient delivery systems for roost toxicants.

N-(3-chloro-4-methylphenyl) hydroxyamine, or C-4-M, has been suggested as a compound that may possess desirable properties in terms of selective toxicity for target species and reduced environmental hazard. Synthesis of this compound is not straightforward, but after correspondence with several research chemists in private industry, a small sample of C-4-M was obtained from a Japanese source. Spectral analysis and melting point determination were performed by a contract laboratory on a sample of the material and results are consistent with the hypothesis that the material is in fact C-4-M and is stable. A bioassay study that compares C-4-M with CPT was planned for FY90.

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Sterner, R.T., S.A. Shumake, R.D. Thompson, and B.E. Johns. 1989. Behavioral-physiological Effects of Red Phosphorous Smoke on Two Wildlife Species. Task 3 Report. (Effects upon the Spontaneous Activity, Startle Response, Pulmonary Function and Blood Chemistry/Hematology of Black-tailed Prairie Dogs (Cynomys ludovicianus) and Rock Doves (Columba livia). Project Order No. 85PP5847, USDA/APHIS, Denver Wildlife Research Center, Denver, CO. 236 pp.

PROJECT TITLE: Monell Field Station

PROJECT LEADER: J. Russell Mason, 215-898-4999

INTRODUCTION:

The control of damage caused by avian and mammalian species often involves the use of chemical attractants, repellents, and toxicants. Successful use of these materials depends on an understanding of the sensory and perceptual capacities of the target organisms. The Monell project is structured to determine relationships between the chemical senses and behavior in a variety of contexts, with the twin goals of improving existing control strategies for the protection of agriculture and providing the empirical bases for the development of new management techniques.

OBJECTIVES:

1. Identify flavor repellents and irritants that can be used to control nuisance waterfowl, manage pest birds in feedlots and reduce nontarget hazards associated with agricultural chemicals.

2. Enhance mammalian (i.e., canid, rodent) bait acceptance through the identification of biological attractants.

3. Discover new avian repellents.

4. Explore conditioned food avoidance methodologies for specific uses in animal damage control.

5. Provide laboratory research in support of the development of avian toxicants (e.g., 3-chloro-4-methylbenzenamine).

ACCOMPLISHMENTS DURING FY89:

D-pulegone, a mint flavor, was tested in 1-cup and 2-cup feeding tests with European starlings (Sturnus vulgaris). Concentrations as low as 0.01% (w/w) significantly reduced consumption by birds in both 2-cup and 1-cup tests. Further evaluation of d-pulegone and similar compounds (e.g., mangone) appears warranted, especially because the same levels that are repellent to birds are also offensive to rodents and canines.

The repellency of secretions produced by nymphs of the azalea lace bug was evaluated in several experiments. The results indicated that (a) green peach aphids were readily consumed, but lace bug nymphs were rarely eaten, (b) adult lace bugs (which lack chemical secretions) are relatively more palatable than nymphs, (c) nymphs dipped in methylene chloride to remove secretion were more palatable than undipped nymphs, and (d) adult lace bugs or green peach aphids treated with nymph secretions (principally a hydrochromone and a diketone), were less palatable than untreated adults or aphids. Consumption of the former nymphs was significantly higher than consumption of the latter, providing strong evidence that nymphs are avoided because of secretions. To test the corollary hypothesis that adults are palatable because they lack secretion (Experiment 4), we treated

adult lace bugs as well as green peach aphids with nymph secretions (principally a hydrochromone and a diketone). Treated insects of both species were avoided while untreated insects were not. Chemicals present in the secretions of lace bugs (and the defensive secretions of other insects) may represent new and effective tools in wildlife management.

Plant secondary compounds that deter insect predation might also serve as bird repellents. This possibility was tested using cucurbitacin, an insect anti-feedant compound present in buffalo gourd and other members of the family Cucurbitacae. The data suggest that ground buffalo gourd is an effective bird deterent at concentrations $\geq$ 2.5%. Because cucurbitacins can be obtained cheaply as an agricultural commodity (in a variety of gourds and squashes), and because it is insecticidal, we believe that further examination is warranted. In particular, that this substance could have utility as an insecticidal "co-factor" in pelleted insecticides (i.e., permitting reduction in the concentration of hazardous insecticide while providing enhanced protection against accidental ingestion of pellets by birds).

In laboratory experiments, carbon disulfide (CS_2) increases the attractiveness of feeding stations to rats and mice. Bait consumption is also increased. We developed a starch xanthate formulation that releases carbon disulfide as it deteriorates. The formulation is attractive to rats when associated with EPA bait, and Dr. James Miller (Mississippi State University) reports that it is superior to any other attractant that he has ever tested. Because starch xanthate was originally designed as a carrier for agricultural chemicals, we now plan to assess whether we can use it to encapsulate zinc phosphide and brodifacoum. This would permit the attractant and rodenticide to be supplied in the same matrix for incorporation into bait substrates.

Two students have joined the project during FY89. Dr. Wally Jakubas (Ph.D., wildlife management, University of Minnesota) is studying whether coniferyl benzoate and related natural products are effective avian feeding deterents and whether they modulate population cyclicity among ruffed grouse. Mr. Donald Norman (M.A., wildlife toxicology, Western Washington University) is a doctoral candidate in the Biology Department at the University of Pennsylvania. His thesis will test the sensory attenuation hypothesis (Clark and Mason, in prep). In brief, the hypothesis states that birds are relatively insensitive in the chemosensory modality used defensively by prey.

Contract funding to Arizona State University was used for several purposes. Funds supported efforts to obtain an Experimental Use Permit (EUP) from the U.S. Environmental Protection Agency. Also, funds were used for the development of an educational and training program to train woolgrowers in the use of conditioned food avoidance methods. Finally, contract funds were used to probe other applications of conditioned food avoidance learning to animal damage control. One such application was exploration of conditioned aversions as a method to deter heron and egret depredation at catfish farms. To date, we have used alpha-chlorolose to capture herons, and have demonstrated that conditioned food avoidance techniques can be

used to dramatically alter the feeding preference hierarchies of individual birds.

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PROJECT TITLE: Florida Field Station

PROJECT LEADER: Michael L. Avery, 904-375-2229

INTRODUCTION:

Project personnel conduct research on various pest bird species in order to identify facets of their behavior and physiology that can be exploited in the control of bird damage to crops, as well as nuisance, health and safety problems caused by birds. Promising bird control techniques are developed and tested, through experimental manipulation, for eventual application in the field. One main emphasis of the project is the development of methods for controlling blackbird damage to sprouting and ripening rice. This effort entails an integrated approach involving population dynamics, roosting behavior, and feeding ecology. A second major effort involves the development of chemicals that can be used to manage concentrations of roosting blackbirds and starlings, including the development of toxicological and hazard data that can be used to support EPA registrations. In addition, project personnel screen and evaluate chemicals for their potential usefulness as bird repellents.

OBJECTIVES:

1. Develop new methods and broaden the scope of existing techniques for controlling agricultural and nuisance bird problems.

2. Develop an integrated approach for alleviating blackbird damage to sprouting and ripening rice.

3. Identify and develop chemicals for management of roosting blackbirds and starlings.

4. Investigate means for reducing bird depredations on Florida blueberry and strawberry crops.

ACCOMPLISHMENTS DURING FY89:

A systematic repellency study was conducted with methiocarb, red dye, and methylpyrazine (a powerful odorant). Reduction in treated food consumption was greater when methiocarb was paired with the visual or odor stimulus than when presented alone. Redwings conditioned to avoid food paired with methylpyrazine continued to exhibit reduced consumption even after removal of the stimulus. The presence of the red dye seemed to interfere with the effectiveness of the methylpyrazine. In a separate study, the presence of a single experienced bird among a flock of 12 redwings significantly reduced the group's latency to locate palatable, untreated food and hastened the avoidance of repellent-treated food. Having 6 (out of 12) experienced birds in the flock enhanced the learning behavior of the flock no more than did just a single experienced bird.

In cooperation with the Texas A&M University Agriculture and Extension Center in Beaumont, TX, a field study was conducted to evaluate the effectiveness of clay-coated rice for reducing bird damage. In two of

three test fields, there was substantially fewer sprouts lost from 1-ac plots sown with coated seed than from adjacent 1-ac control plots. In the third test field, sprout counts revealed no effect of the treatment, but at this site, bird observations showed 14 times more bird use of the control than of the treated plot, and feeding rates were reduced 82% in the coated seed plot relative to the control. The results of this study are consistent with previous findings and additional development is warranted. Details of the study are provided in Bird Section Research Report 444.

A cooperative agreement with the University of Florida Institute of Food and Agricultural Sciences, Fruit Crops Department, was initiated in order to evaluate the potential for altering the sugar composition of blueberries. Fruits of approximately 50 cultivars and several wild species were collected at various stages of development. Sugar composition of developing and mature blueberry fruit harvested from wild species as well as from breeding lines in the UF germplasm collection is being analyzed. Initial work has focused on developing the methodology for carbohydrate extraction and quantification. The blueberry species and breeding lines being analyzed include several cultivated highbush clones (Vaccinium corymbosum cultivar Flordablue, Sharpblue, O'Neal, Avonblue), highbush selections, and wild highbush clones; several cultivated rabbiteye clones (V. ashei cultivar Bonita, Brightwell, Climax). and rabbiteye selections; V. darrowi selections, wild V. stamineum, four fruit developmental series, and a fruit size series from the germplasm collection. Preliminary HPLC analysis indicates that, as expected, cultivated mature blueberry fruit (both V. corymbosum and V. ashei) have low sucrose concentrations (approx. .01 and .03 M). However, sucrose concentrations in V. stamineum are significantly higher, ranging from .06 to .15 M. This suggests that V. stamineum may be useful in breeding blueberry fruit with higher sucrose levels.

Bird damage information collected in 1988 and 1989 in growers' fields and at the University of Florida Horticulture Unit was analyzed and summarized. Results showed substantial damage by birds (17%-75%), especially when superimposed on crop loss due to adverse winter weather. Caged feeding trials with cedar waxwings showed that 1.0% (w/w) methyl anthranilate (MA) suppressed consumption of banana mash almost completely, while reduced concentrations (0.25% and 0.5%) were somewhat less effective. Similar results were obtained when MA was applied to whole blueberries, although the birds persisted in sampling the treated fruit. Flight pen trials confirmed field observations that mylar reflecting tape and eyespot balloons are ineffective in protecting blueberries from cedar waxwing depredation. Field application of formulated MA on blueberry bushes showed considerable phytotoxic effects at each level tested (4 lb/ac to 24 lb/ac).

A test was conducted in the flight pen to gain knowledge of the relative toxicity of the two closely related toxicants CPT and CPTH (3-chloro-4-methylbenzenamine HCL) and of the most effective application methodology. Starlings were individually sprayed with CPT or CPTH applications differing in droplet size and level of toxicant. Results showed no obvious effect of droplet size on mortality and little toxicological difference between CPT and CPTH formulations.

A comprehensive report was prepared that summarized and compared available data on the physical, chemical and toxicological properties of DRC-1347 (CPT) and DRC-1339 (CPTH). The current data base for these two compounds does not support a clear preference for development as a roost toxicant. Data related to potential environmental fate of the two compounds is lacking and will need to be collected before an objective choice can be made.

A research project to monitor and evaluate the use of DRC-1339 brown rice bait for controlling blackbird populations at the Miller's Lake roost in Evangeline Parish, Louisiana, was completed. Although the baiting program remains difficult to fully assess, three pieces of circumstantial evidence suggested that the program was successful in reducing blackbird populations and damage. These included almost total elimination and/or abandonment of the roost by March 30 (almost 1 month prematurely), significant reduction in foraging blackbirds within a 5-mile radius of the roost compared to previous years and that 33 growers responding to a posttreatment questionnaire indicated an 80% reduction in sprouting rice damage compared to previous years. No conspicuous nontarget hazards were identified.

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PROJECT TITLE: Ohio Field Station

PROJECT LEADER: Richard A. Dolbeer, 419-625-0242

INTRODUCTION:

Over two-thirds of the U.S. human population and about three-fourths of U.S. blackbird and starling populations reside east of the Mississippi. The greatest concentration of gulls and Canada geese in North America also occurs in the midwest and northeast U.S. Bird-people conflicts in this area are increasing with the increase in human population and intensified land use for food production, recreation, and housing. Ohio is a central location for these conflicts because breeding and late summer roosting populations of blackbirds and starlings, and migratory populations of some gull species, reach their highest levels in the Great Lakes region. As examples, blackbird damage to corn currently is estimated to be over $4 million annually in Ohio alone, and the substantial (20-fold) increase in gull populations on the Great Lakes in the past 20 years has created a variety of agricultural, safety and nuisance problems. Canada geese, because of population increases and adaptation to suburban environments, are creating similar problems throughout the midwest and northeast.

Project studies are oriented to developing practical solutions to midwestern and northeastern bird problems. Emphasis is on the population ecology of pest birds and the development of control methods for reducing conflicts. Population ecology studies attempt to monitor and explain population trends of pest species throughout the U.S. and to evaluate the impacts of various levels of population reductions. Control-methods development explores a number of cultural, repellent, frightening, and lethal techniques for reducing agricultural damage and other conflicts caused by federally protected migratory birds.

OBJECTIVES:

1. Evaluate DRC-1339 and other methods such as overhead wires for resolving conflicts between gulls and people.

2. Evaluate alpha-chloralose as an immobilizing agent in managing goose and possibly crow and gull populations.

3. Evaluate predator effigies and eyes for repelling starlings and other hole nesters from nesting sites.

4. Monitor population trends and model population dynamics of pest birds species in North America.

5. Develop methods for reducing woodpecker damage to houses and wooden utility poles.

ACCOMPLISHMENTS DURING FY89:

A revised label which we developed was submitted to EPA. This label expanded the use of DRC-1339 as a gull toxicant to coastal areas nationwide

and to include ring-billed gulls (it previously was restricted to herring and great black-backed gulls in eight northeastern states). EPA accepted the label changes. DRC-1339 is still restricted to use in association with the management of nesting colonies of other, threatened waterbirds.

Project Leader served on an expert panel whose purpose was to resolve conflicts between and make recommendations to the National Park Service and JFK International Airport concerning the hazard to aircraft safety presented by an expanding colony of laughing gulls on the NPS Joco Marsh. Project Leader was instrumental in achieving a compromise by which the NPS affirmed the hazard presented by the colony and agreed to implement a management plan involving egg destruction in gull nests at the marsh.

Initial LD_{50} and TI_{50} testing of alpha-chloralose (AC) was done on mallards and Canada geese. In addition, a preliminary test revealed moderate food deprivation had no impact on A-C effectiveness for Canada geese.

Eleven field trials were done in conjunction with ADC personnel to develop baiting techniques for AC. About 650 nuisance waterfowl (ducks, geese and coots) were captured with minimal mortality except under hot (>85°F) conditions. In addition, A-C showed promise for capturing pigeons: 230 were taken in one 3-day trial. Public reaction to these tests was favorable.

A literature search was made and report written to document the status of double-crested cormorant populations in North America and to project annual growth rates in the population (Dolbeer 1989).

A series of computer simulations were run of the North American red-winged blackbird population to demonstrate the level of impact of the current ADC roost spray program on regional populations. This information has been incorporated into the draft EIS on the ADC program.

The literature was searched to determine population status and trends for the laughing gull on the east coast. These findings were incorporated into a publication dealing with the management of laughing gulls on National Park Service land near JFK airport International Airport.

Six walls were established in wooded areas on NASA Plum Brook where woodpecker activity was observed. These walls have been monitored for 4 months, but no damage has occurred to date. Testing woodpeckers in captivity was not undertaken in FY 1989.

In cooperation with New York ADC personnel, six hybrids of field corn (three predicted to be resistant and three predicted to be susceptible) were planted near Montezuma National Wildlife Refuge (MNWR), New York, in six replicated blocks. Damage will be assessed in early October 1989. The plantings were on a farm that has been plagued with blackbird damage to corn in previous years.

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PROJECT TITLE: Mississippi Field Station

PROJECT LEADER: Donald F. Mott, 601-325-8215

INTRODUCTION:

The primary purpose of this project is to develop methodology to reduce depredations by fish-eating birds at commercial fish, shellfish, and baitfish farming facilities. Aquaculture has become a major industry in Arkansas, Louisiana, Mississippi, and Texas in the last few years. With growth in the industry has come increases in predation by fish and shellfish-eating birds together with possible disease transmission by these birds from pond to pond and season to season. Emphasis will be placed on gathering data on the extent of these problems and developing effective methods of control.

OBJECTIVES:

1. Determine the scope and severity of bird problems at aquaculture facilities in the states listed above with emphasis on catfish farms in Mississippi.

2. Develop techniques to reduce bird depredation and disease transmission caused by birds at aquaculture facilities.

ACCOMPLISHMENTS DURING FY89:

A cooperative agreement with scientists located at Mississippi State University was established for the purpose of studying the roosting dynamics of cormorants in the Delta Region of Mississippi. Project start-up was initiated August 1989 with a review of literature pertinent to cormorant roosting activities. Knowledgable individuals were contacted regarding locations of recent cormorant roosting sites. Results of waterfowl surveys of catfish ponds conducted from 1984 through 1989 were reviewed to assess the magnitude of cormorant use of these wintering habitats.

A study was conducted at three cormorant roost sites to determine if roost dispersal would result in reductions of cormorant depredations at nearby catfish ponds. Although cormorants appeared to be easily frightened from roosts by ground-based and aerial harassment, the effect on damage reduction was less evident. After dispersal, some short-term reduction of bird pressure at nearby ponds was recorded during aerial surveys; however, the birds formed new roosts at the closest available roost habitat or at nearby historical sites. Cormorants continued to feed at catfish ponds near these areas. The simultaneous harassment of cormorants at two roosts (10 miles apart) by helicopter, fixed-wing, and ground based harassment resulted in the birds flying between roosts, adapting somewhat to aerial harassment by diving into the water rather than leaving the site, or temporarily relocating to other unharassed roost sites. Based on this study, in order to reduce damage it would appear that all potential roost sites would have to be harassed at the same time in order to move

cormorants out of the region. This would require an extremely large manpower pool and resources for ground and aerial harassment.

As a first step in assessing the impact of birds on the catfish industry, Mississippi catfish growers were surveyed by telephone to gather information on the impact of piscivorous birds on commercial catfish operations. Piscivorous birds were enough of a problem to 94% of the growers to warrant then conducting bird harassment activities. Driving around the ponds and firing at the birds to repel them was the primary harassment technique used by 90% of these growers. The total annual cost for harassing birds for these growers amounted to roughly $1.5 million. This amount does not include the value of fish lost to birds.

Aerial reconnaissance of cormorant populations was attempted, and the results indicate that such reconnaissance is feasible, and is probably the only preferred way to obtain adequate estimates of cormorant populations on catfish ponds. Aerial reconnaissance of great blue heron populations was also attempted and found to be useful for locating pond complexes that have heron populations. Ground observations made by driving around a pond complex several times a day seemed to provide a fairly accurate count of the number of herons using a particular complex. Aerial reconnaissance of great egrets would also appear to be the best way to census their populations. However, censuses per se of great egrets were not made at this time because great egrets are a problem of lesser priority.

A technique was developed for determining the number and size of catfish cormorants can take per minute. It first entails determining the length of time the cormorants on a particular pond take to handle catfish before swallowing them. Then one observer counts cormorants arriving and departing the pond on a minute-by-minute basis while a second observer scans the cormorants on the surface of the pond for the presence and size of catfish (or other fish) in their bills. All cormorants would be flushed from the pond at the end of the observations so that the minute-by-minute cormorant populations counts can be adjusted for the birds present on and in the pond at the time the observation was started. These procedures should provide an estimate of the pounds of catfish taken per cormorant-minute on a pond.

A technique for determining the amount of catfish caught per great blue heron minutes spent at pond complexes was also tentatively established. It involves driving the dikes of the ponds to determine the number of herons present on the complex. These counts would be used to determine the total number of heron-minutes spent on the complex in a day. Individual birds would be observed through spotting scopes and the length of time a bird is watched and the species, number, and length of fish taken during that time would be recorded.

A search of the literature on the energetics of fish-eating birds was begun to assess the feasibility of conducting energetic modeling studies. Cormorant food habit collections made by ADC during FY89 were reviewed to judge their appropriateness for the energetics study and for assessing future food habit collection needs. Trapping techniques for cormorants were investigated and an unsuccessful attempt was made to capture

cormorants in the Mississippi Delta before they left the area in the spring. Cormorants were subsequently captured in the Denver area and will be used in the design of a radio transmitter package by the DWRC Bioelectronics Project.

REPORTS AND PUBLICATIONS:

None

PROJECT TITLE: Kentucky Field Station

PROJECT LEADER: Donald F. Mott, 502-842-0341

INTRODUCTION:

The primary emphasis of this project is to develop methodology to reduce problems associated with winter roosting blackbirds and starlings. Blackbirds and starlings concentrate in the southeastern U.S. where an estimated 440 million birds congregate in 260 large roosts each winter. The roosts are of concern because of human and livestock health hazards (e.g., histoplasmosis and transmissible gastroenteritis), agricultural damage to sprouting and ripening crops, consumption of livestock feed in feedlots, and other hazards including bird aircraft strikes.

The Kentucky Field Station was closed in June 1989. Prior to official closure, Project personnel were reassigned to other Projects, and the Project Leader also served as leader of the Mississippi Field Station.

OBJECTIVES:

1. Develop methodology to evaluate the effectiveness of CPT (DRC-1347) spray applications for controlling blackbird and starling roosting populations.

2. Develop and evaluate improved delivery techniques of avicides used for reducing agricultural, health, and safety problems associated with winter roosting blackbirds and starlings.

3. Develop techniques to reduce blackbird and starling damage at livestock feeding operations.

ACCOMPLISHMENTS DURING FY89:

A 2.2 ha woodlot roost site near Crawford, Mississippi, containing about 330,000 blackbirds and starlings was treated by helicopter the night of 1 March 1989 with a 468 l/ha (50/gal/a) CPT-Avicide formulation containing approximately 56.8 kg CPT active ingredient/ha (50 lb/a). Total treatment releated mortality occurring within the roost was estimatetd to be 9500 blackbirds and starlings. Mortality occurring away from the roost, estimated by roost counts, monitoring of radio-tagged birds, sampling of surviving birds exiting the roost, and monitoring of blackbird numbers within the birdshed of the roost, indicated a 10-50% population reduction with most mortality occurring within 3 days following treatment. The impact of this spray on nontarget species appeared minor. Hawk and owl numbers in and near the roost did not decline following treatment nor did hawk numbers within the birdshed of the treated roost. Dead nontarget birds found during posttreatment roost searches included 10 cardinals (Cardinalis cardinalis) and 1 robin (Turdus migratorius). Nine of the 11 nontarget bird mortalities showed signs of CPT poisoning. TLC plates and soil and vegetative samples collected after the spray have yet to be analyzed. Information from these analyses will help determine how much

chemical reached the birds, was intercepted by roosting vegetation, and how much may have missed the target area.

Project personnel assisted in the evaluation of the effect of droplet size and concentration level of DRC-1347 (CPT) and DRC-1339 (CPTH). Refer to the Florida Field Station report.

A series of laboratory experiments were conducted to determine the lowest effective concentration of MA in feed that would be as effective as the previously field tested 1.0% starch entrapped DMA formulation. Results indicated that both 0.4% and 0.5% MA were as effective as 1.0% DMA. Projected costs of MA treatment approached 10% the cost of feed and based on other factors was judged to be worthy of further investigation.

REPORTS AND PUBLICATIONS:

Glahn, J.F., A. Wilson, and P.W. Lefebvre. 1989. A preliminary evaluation of baiting preroosting assemblages of blackbirds with DRC-2698 (CAT)-treated brown rice for reducing sprouting rice damage. Denver Wildlife Research Center, Bird Section Research Report No. 437. 9 pp.

PROJECT TITLE: North Dakota Field Station

PROJECT LEADER: George M. Linz, 701-237-7054

INTRODUCTION:

Blackbirds cause significant damage to ripening sunflower in the Dakotas and Minnesota. In 1980, losses were estimated to be $6.5 million, and the problem continues to have high priority within the ADC Program. Congressional budget language consistently emphasizes the importance of reducing the magnitude of these losses. This Project is responsible for developing an integrated bird damage management system in sunflower. Current objectives include development of a roost toxicant that could be used to selectively reduce damaging populations, and evaluation of alteration of roosting habitat, largely cattail marshes, as a tool to eliminate roosts near sunflower fields and enhance these marshes as habitat for other species of birds, especially waterfowl. A cooperative agreement between researchers at North Dakota State University and the DWRC has the objective of developing commercially viable hybrids of sunflower that possess morphological characteristics that make them resistant to blackbird feeding. Supporting research projects also are designed to increase understanding of migrational and seasonal distribution patterns, roosting and flocking behavior, population trends, and food habits of redwinged and yellowheaded blackbirds and common grackles.

OBJECTIVES:

1. Assist in development of a contact roost toxicant for reducing blackbird populations in the sunflower growing region.

2. Evaluate the effectiveness of using fire and mechanical devices for reducing blackbird nesting and roosting habitat in sunflower growing areas of North Dakota.

3. Study the migratory movements, distribution, population turnover rates, and total numbers of blackbirds using roosts in the northern Great Plains relative to fall sunflower losses in the Dakotas and Minnesota.

4. Collaborate with scientists at North Dakota State University to develop bird resistent sunflower hybrids and study the ecology of damaging species.

ACCOMPLISHMENTS DURING FY89:

Refer to the report of the Kentucky Field Station for a description of progress made in development of a lethal roost toxicant. The North Dakota Field Station Project Leader was a co-principal investigator for the Mississippi field study that was conducted in FY89. Permission to conduct field studies in North Dakota in FY89 was not obtained from EPA.

Seventy percent of the cattails in four marshes were aerially sprayed with Rodeo herbicide during August and September at a rate of 2.5-3.0 qts/ac in a 5-gal/ac aqueous solution. The untreated cattails (30%) consisted of 45-

ft wide strips. Blackbirds and nontarget animals in and around the marsh were enumerated pre- and post-treatment. Surveys of blackbirds using sunflower fields within 2 miles of the treated marshes were conducted. In addition, three application rates of Rodeo (0, 1, 2, 3 qts/ac) were applied in 8-ft. strips by ground sprayer in one marsh. Initial data indicate that Rodeo herbicide applied aerially at about 3 qts/ac in a 5-gal/ac aqueous solution is effective in killing low to medium density stands of cattails but may be inadequate for killing heavy stands of cattails. A solution containing 3 qts/ac Rodeo in a 10-gal/ac solution may be more effective on heavy stands of cattail. Pre- and post-treatment population estimates of target and nontarget birds in the marshes were similar. There were no differences in the number of blackbirds observed in the sunflower fields pre- and post-treatment. The effectiveness of the herbicide applications will be evaluated in July 1990 by determining the density of emerging cattails in the treated marshes. Heavy rains in late August - early September precluded burning or mechanically crushing the cattails in the treated wetlands.

Scientists at North Dakota State University, under contract with the Denver Wildlife Research Center, continued research on developing a commercially viable sunflower hybrid that possesses morphological characteristics that make it resistant to blackbird feeding. Four morphological features, which may protect sunflower from depredation, are long, heavy involucral bracts, horizontally oriented heads, head-to-stem distances greater than 15 cm, and concave-shaped heads are being tested. Sunflower showing these morphological traits and good agronomic qualities were evaluated in small plots on the NDSU campus and at five locations in North Dakota with historically high blackbird populations. Genotypes that performed well in these environments will be selected and again evaluated in 1990 for those same qualities. Field research was completed for a thesis project designed to determine the effect of environment on the expression of morphological traits that confer bird resistance. These data will be analyzed in FY90. If a trait is greatly affected by environment, its usefulness as a bird deterrent will be limited.

Experiments were also conducted to quantify the effectivenss of individual bird-resistant traits possessed by bird resistant sunflower. In these trails, the role of hull thickness, head shape, involucral bracts, and head-orientation were tested. A methodology was developed whereby the effectivenss of these traits for deterring blackbird feeding was compared against the amount of white millet and green foxtail normally consumed by red-winged blackbirds. Initial analysis of the data indicate that concave heads facing downward may be the most important morphological trait for deterring blackbird feeding. Bracts and hull thickness do not appear to significantly deter bird feeding on sunflower. Further experimentation is needed to confirm these results. These data will be used to help select sunflower genotypes with potential bird resistant traits.

An experiment was conducted to determine the ability of red-winged blackbirds to discriminate between sunflower containing different amounts of oil. Thirty male red-wings were given a choice between 2 cups of achenes chosen from four sunflower varieties that differed in oil content (35%, 40%, 47%, and 52.5%). Whole sunflower achenes were tested in the

first experiment, dehulled achenes in the second. Red-wings were able to discriminate differences in oil-content between achenes containing 35% and 40% oil. This discrimination became less sensitive when high-oil achenes (47% vs 52.5%) were presented. The results also suggest that the bird's ability to discriminate was more sensitive when achenes were intact than when the hulls were removed.

Yellow-headed blackbirds are often seen in sunflower fields with other blackbird species. Scientists at North Dakota State University are completing a study designed to investigate the ecology of these birds in relation to sunflower. A large portion of the male's diet was found to be sunflower, whereas, females consumed very little sunflower. Alternate foods for both sexes included small grains and weed seeds. In addition, a mathematical model is being developed to help discern the origin of yellowheads found feeding in North Dakota. Finally, the relationship of the bird's annual feather molt with fall migration is being analyzed. The results of these studies will be published in FY90.

Common grackles are the largest of the blackbird species feeding on sunflower. Thus, their potential for causing large sunflower losses is a concern. The food habits of grackles and the size of their breeding population in Benson County, North Dakota, a large sunflower producing area, is currently being studied by scientists at NDSU. In 1989, there was an estimated 27,706 breeding pairs of grackles. Sixty percent of the birds nested in residential shelterbelts surrounding inhabited farms, 13% in towns, 12% in agricultural shelterbelts, 7% in shelterbelts surrounding uninhabited farms, and 8% in other habitats. The most common species used by grackles for nesting were elm (25%), spruce (17%), boxelder (13%), caragana (11%), and ash (7%). In addition, red-winged and yellow-headed blackbirds and common grackles were collected for a comparative food habits study. The data will be analyzed in FY90.

REPORTS AND PUBLICATIONS:

Friend, T. J. 1989. Inheritance of anthocyamins in hulls of sunflower. M. S. Thesis. North Dakota State Univ., Fargo, North Dakota. 58 pp.

Gross, P. 1989. Effects of environment on the expression of morphological traits associated with bird resistance in sunflower (Helianthus annuus L.). 1989. Proc. V Great Plains Sunflower Insect Workshop. Fargo, North Dakota. 10 pp.

Hanzel, J. J. 1989. Development of bird resistant sunflower. 1988 Annual Rept. for USDA-APHIS-ADC Project ND03621. 20 pp.

Hanzel, J. J. 1989. Bird resistant sunflower. Proc. Sunfl. Res. Workshop. Fargo, North Dakota. 23-25 pp.

Linz, G. M., J. L. Cummings, J. E. Davis, Jr., C. E. Knittle, and J. J. Hanzel. 1989. 1987 sunflower crop in Benson and Ramsey Counties, North Dakota: yield, oil content, and blackbird damage. Proc. Sunfl. Res. Workshop. Fargo, North Dakota. 25-26 pp.

Linz, G. M., M. L. Avery, J. F. Besser, J. B. Bourassa, J. L. Cummings, J. E. Davis, Jr., R. A. Dolbeer, R. M. Engeman, C. E. Knittle, D. F. Mott, D. L. Otis, and E. W. Schafer, Jr. 1989. Treatment of two blackbird roosts in North Dakota with a simulated CPT-Avicide formulation. Unpubl. Bird Damage Res. Rept. No. 435. Denver Wildl. Res. Ctr., APHIS, Denver, CO. 70 pp.

Olafson, J., W. J. Bleier, G. M. Linz, L. J. Linz, and R. B. Carlson. 1989. Geographic variation in the Red-winged Blackbirds from Central North America. Proc. Sunfl. Res. Workshop. Fargo, North Dakota. 28 pp.

Twedt, D. J., W. J. Bleier, and G. M. Linz. 1988. Geographic origin of yellow-headed blackbirds associated with sunflower depredations in central North Dakota. Unpubl. Progress Rept. No. 3. Department of Zoology, North Dakota State Univ., Fargo, North Dakota. 9 pp.

Twedt, D. J., W. J. Bleier, and G. M. Linz. 1989. Geographic origin of yellow-headed blackbirds associated with sunflower depredations in central North Dakota. Unpubl. Progress Rept. No. 4. Department of Zoology, North Dakota State Univ., Fargo, North Dakota. 7 pp.

Twedt, D. J., W. J. Bleier, and G. M. Linz. 1989. Blackbirds with yellowheads, Do they eat sunflower too? Proc. Sunfl. Res. Workshop. Fargo, North Dakota. 27-28 pp.

PROJECT TITLE: Avian Chemical Methods

PROJECT LEADER: C. Edward Knittle

INTRODUCTION:

An integrated approach to controlling problem bird species utilizes many diverse methods of control, including chemical agents. This Project has primary responsibility for providing data on avian chemicals (avicides, repellents, immobilizing agents) to support the registration of APHIS/ADC. The Project is responsible for maintaining existing registrations of chemicals used to control blackbirds, starlings, and gulls, for expanding uses of existing registrations, and for fulfilling data requirements to support registration of new avian chemicals. Efforts to develop, register, or expand uses of avian control agents require a continuing collaborative effort among personnel of the Bird Control Research Section and the Section of Chemical Development/Registration.

OBJECTIVES:

1. Convert Special Local Need (24C) registrations for DRC-1339 into Federal Section 3 registrations.

2. Develop data to support the registration of CPT for blackbird/starling roosts.

3. Develop data on efficacy of DRC-1339-treated egg baits by determining the fate of radio-instrumented ravens.

4. Provide technical assistance as needed.

ACCOMPLISHMENTS DURING FY-89

In July and August, 1988, two amended labels for Compound DRC-1339 98% Concentrate were submitted to EPA. The first label, EPA Reg. No. 56228-17, expanded 1339 use for control of great black-backed and herring gulls to include ring-billed gulls, and expanded the limitation-of-use area from the northeastern U.S. to nation-wide. Following minor changes, the EPA granted the amended gull label in February 1989. This label does not yet reflect 1339 use in other gull nuisance situations such as landfills and airports. An attempt will be made in FY-90 to further amend this label to include these uses. The second amended label, EPA REG. No. 56228-10, was written to clarify and expand 1339 uses in feedlots, and to include three other uses: 1) control of corvids (primarily ravens) involved in depredations of livestock, the eggs of nesting waterfowl, and the eggs/young of certain threatened/endangered species; 2) control of nuisance birds, primarily blackbirds and starlings, by baiting congregating/staging areas; and 3) control of pigeons in and around structures. In April 1989, the EPA rejected the proposed amendment to 56228-10, but submitted a number of suggestions to improve this label and identified data gaps that needed to be filled for 1339 before resubmission would be possible. APHIS subsequently determined that its needs would be better served by separating the original amended label requested for 56228-10 into four different

registrations as identified above. To fill the data gaps indicated by EPA, Operations and DWRC formed a DRC-1339 Working Group to review EPA's suggestions and scrutinize the existing 1339 data. Subsequently, two of the four proposed registrations were submitted to EPA in late September and early October. The remaining two registrations will be submitted in late October of FY-90. These registrations, if granted, would consolidate as many as 15 Special Local Need Section 24(c) registrations. Existing data were submitted to support these registrations for Guidelines 71-1. (acute avian oral, quail/duck), 71-2 (acute avian dietary, quail/duck), 72-1 (fish toxicity, bluegill/rainbow trout), 72-2 (invertebrate toxicity), 81-1 (acute oral toxicity, rat), 81-2 (acute dermal toxicity, rabbit), and 96-5 (product performance). Because most of these data were gathered prior to the implementation of Good Laboratory Practices requirements, registrations were requested based on the submission of existing data but with the understanding that APHIS will provide new data that meet GLP.

In February 1989, in collaboration with the BCRS, an experimental application of CPT Avicide was applied on roosting blackbirds near Crawford, Mississippi. The objective was to test several efficacy evaluation methods, including the use of radio-instrumented birds and a blood assay method, and to gather residue and other pertinent data for future submission of an EUP to EPA for further testing. A single application of 50 gallons per acre of CPT (10% a.i.) was aerially applied at night by helicopter to approximately 330,000 blackbirds and starlings occupying a 6-acre mixed cedar/hardwood roost. Preliminary results showed an estimated kill ranging from 10 to 50%, depending on the evaluation method used. Spray application was not completely satisfactory and contributed to the variable results.

In May and June, a U.S. Navy funded research project was conducted on Camp Pendleton Marine Base near Oceanside, California in cooperation with the BCRS. The objective was to determine involvement of common ravens in the depredation of eggs of the endangered California least tern nesting on the ocean beaches of the Base. Twenty-one adult or second-year ravens were captured, radio-instrumented, and tracked to determine their daily activities and movements relative to the tern colonies. Ten nestlings were also captured and tagged with patagial markers. Preliminary results indicate that ravens posed little threat to tern eggs this year; there were no known depredations of tern eggs by radio-instrumented ravens. One tagged fledgling was shot by ADC personnel when observed flying over one of the colonies while carrying an egg. Other avian and mammalian predators caused significant losses of tern eggs and nests. This study has been funded again in FY-90 and will focus primarily on testing DRC-1339 in hard-boiled chicken eggs to control ravens.

Alpha-chloralose is an immobilizing agent that can be used to capture waterfowl for subsequent relocation or immobilization. A contract was established with Wildlife Laboratories of Ft.Collins, CO, to determine the data requirements for obtaining an FDA registration and to begin the required paperwork.

In October, at the request of the U.S. State Department and the Section of International Programs, DWRC, approximately three weeks were spent by the

Project Leader in Senegal, West Africa, serving as an Environmental Specialist investigating human and wildlife hazards of insecticide sprays used to control desert locust.

Consultation and information was provided to ADC Operations in Texas concerning the feasibility of using aerial mass-marking to determine movements and turnover rates of great-tailed grackles causing damage to citrus in the lower Rio Grande Valley.

Consultation was provided to U.S. Navy biologists in San Diego concerning control methods useful in protecting the endangered least shrike from feral cats on San Clemente Island off the coast of Califormia.

Consultation and information on various uses of DRC-1339 was provided to 1) ADC Operations in Arizona for the control of ravens causing livestock depredations, and blackbirds and starlings in feedlots, 2) ADC Operations in New Mexico to acquire a 24(c) to control ravens and crows involved in damage to livestock and fruit and nut orchards, 3) ADC Operations and the BLM in California to acquire a 24(c) to control ravens preying on the endangered desert tortoise in the Mojave Desert, 4) biologist at DWRC Mississippi Field Station and Louisiana ADC to acquire a 24(c) to control blackbirds in rice stubble by baiting staging areas.

PRESENTATIONS:

Knittle, C.E. 1989. Environmental hazards of pesticide applications in foreign countries. Presented at the Second International Short Course on Vertebrate Pest Management at Colorado State University.

PROJECT TITLE: Predator Chemical Registration and Research

PROJECT LEADER: Peter J. Savarie, (303) 236-7866

INTRODUCTION:

This project evaluates chemicals in laboratory, pen, and field studies for managing predators. Laboratory toxicity and efficacy tests are conducted to assess possible effects of chemical control products on humans, nontarget wildlife, domestic animals, and the environment and to supply the data required by EPA for chemical registration. Inert markers for control products are developed to replace markers currently in use that have been classified hazardous by EPA. In addition, physiological markers are evaluated and used to identify target and nontarget species to assess efficacy and selectivity of chemical delivery methods. This project cooperates with other Sections in development of required registration data, and coordinates research with contract laboratories.

OBJECTIVES:

1. Develop data to register single dose baits (SDBs) for predators.

2. Develop data to maintain the registration of livestock protection collars (LPCs) for managing coyote predation.

3. Investigate the use of oral tranquilizers as a future tool for ADC use.

4. Develop inert markers for identification of chemical control products.

5. Develop physiological markers as a means for determining efficacy and selectivity of control techniques.

6. Develop data to register the 2-ingredient gas cartridge for rodents.

ACCOMPLISHMENTS DURING FY-89:

Technical support and consultations about nontoxic marker single dose baits (SDBs) were provided to personnel in the Predator Control Research Section who conducted field evaluations to assess efficacy and selectivity of baiting strategies to target (coyotes) and nontarget species.

A protocol for estimating the amount of 1080 delivered to coyotes from the Livestock Protection Collar (LPC) was submitted to EPA for comment. From subsequent discussions, it was the opinion of DWRC and EPA personnel that this type of study would not provide meaningful, practical data to assess environmental hazards. Consequently, a revised protocol was submitted to EPA to determine 1080 contamination on coyote-killed collared sheep. Upon EPA's approval of this protocol, the study will be conducted and the data obtained will be used in tests to assess primary hazards of the 1080 LPC to skunks and golden eagles.

Inquiries on the availability of tranquilizers suitable for use in the trap tab were addressed to several companies. A source for propiopromazine was

located from Bayer Chemical Co., Germany through Mobay Chemical Co., USA, and arrangements were made to obtain a supply for testing. Discussions were held with FDA and this project cooperated with Predator Control Research Section personnel in development of a draft protocol for field evaluation of trap tabs.

Project cooperated with Predator Section personnel in the development of GT-15-N (Blaze Orange) as a replacement marker for Tracerite in the M-44 and tartrazine as a replacement marker for rhodamine B in the 1080 Livestock Protection Collar.

Several candidate physiological markers have been identified and will be evaluated as resources become available. Technical assistance was provided to personnel within and outside DWRC on the use of iophenoxic acid (IA) as a marker and arrangements were finalized for analysis of IA samples by a contract laboratory.

Pilot studies were conducted with prototype rodent gas cartridges containing 2 ingredients (65% sodium nitrate and 35% charcoal). Burn time characteristics did not meet EPA specifications. A source for a cartridge that contains a flame retardant was located and a contract laboratory was selected for analysis of the 2 ingredients in the gas cartridge.

In cooperation with the Strychnine Consortium, this project monitored contract studies for strychnine data-call in requirements for aquatic organism (rainbow trout, bluegill sunfish, Daphnia magna) and avian (mallard ducks, bobwhite quail) toxicity tests.

PUBLICATIONS AND REPORTS:

Burns, T.J., G. Connolly, and P.J. Savarie. 1988. Large livestock protection collars effective against coyotes. Proc. Vertbr. Pest Conf. 13215-219.

Hadidian, J.S. Jenkins, D. Johnston, P. Savarie, V. Nettles, D. Manski, and G. Baer. 1989. Acceptance of simulated oral rabies vaccine baits by urban raccoons. J. Wildl.. Diseases 25(1):1-9

Burns, R.J., and P.J. Savarie. In Press. Persistence of tartrazine in marking sheep wool. 4th Eastern Animal Damage Control Workshop, Madison, Wisc., Sept. 25-27, 1989.

Burns, R.J., and P.J. Savarie. 1989. Persistence of tartrazine (FD&C Yellow #5) in marking sheep wool. DWRC Final Report. 12pp.

PROJECT TITLE: Pesticide Formulation

PROJECT LEADER: Melvyn V. Garrison, (303) 236-7862

INTRODUCTION:

Several vertebrate pesticides that are currently registered or are scheduled to be registered in the future will require an improved formulated product. This project works on improvements in the formulation of currently registered compounds and provides new formulations for those pesticides yet to be registered. The project cooperates with other sections to provide biologists with formulated products for laboratory efficacy testing and for field evaluation testing.

OBJECTIVES:

1. Develop formulated avicides to be evaluated against birds in sprouting rice crops.

2. Formulate strychnine and zinc phosphide baits using GLP methods to assist in maintaining USDA/APHIS registrations.

3. Assist in development of single-dose predacide formulations.

4. Develop new formulations for other Sections and evaluate the performance and safety of those vertebrate pesticides.

ACCOMPLISHMENTS DURING FY-89:

In response to a request by the Bird Control Research Section for a DRC 1339 bait to protect emerging rice in Louisiana, several formulations were prepared and were tested in the laboratory for acceptance by this project. Further evaluation of the formulations was completed at the Gainesville Field Station. One formulation, DRC 1339/medium brown rice/Alcolec S, was selected for field testing at Crowley, Louisiana by DWRC Bird Section and ADC personnel. Approximately 250 lbs. of a 2.0% DRC 1339 bait were prepared and shipped to Crowley.

In response to a request from the Mammal Control Research Section (MCRS) for compound 1080 formulations, six formulations were prepared for laboratory testing on the northern and plains pocket gophers. Low levels of 1080 baits were also prepared for field evaluation on the Columbian ground squirrels.

Eight requests for formulations of the experimental control agent, Quintox, were completed and given to the MCRS for laboratory testing on pocket gophers and ground squirrels. A total of twenty (20) formulations were prepared.

In response to a request by MCRS for strychnine formulations, three different baits were developed, using molasses, Alcolec S, and Rhoplex AC-33 as adhesives on squirrel oats and Milo. There were two molasses formulations prepared for laboratory studies, while 15 and 8 formulations

of Alcolec S and Rhoplex AC-33 were prepared, respectively. For field evaluation on pocket gophers, 14 formulations were prepared with the latter two adhesives.

For a year long storage stability test, formulations of strychnine paste (1.6 and 4.9%) and a 0.4% strychnine pigeon bait were prepared to obtain necessary data for EPA. A new formulation of the paste was developed to maintain strychnine in solution rather than allow it to settle out.

In response to a request from the Olympia Field Station, two trips were made to the Pocatello Supply Depot during May and August. The purpose of the trips were to assist in GLP and Quality Assurance in strychnine bait preparation to be used in field studies.

A request from the Predator Damage Control Section for an acceptable bait which could be used to deliver an anti-rabies vaccine to wild raccoons was completed. Two highly preferred baits were developed. One bait used a foam sleeve that was dipped into a modified Jiffy corn muffin mix and deep fried in corn oil. The second bait also used the foam sleeve, but was dipped into a modified Pillsbury corn dog mix and deep fried.

PROJECT TITLE: Chemical Research Project

PROJECT LEADER: Roger W. Bullard, (303) 236-7811

INTRODUCTION:

When an animal damage control chemical is being considered for an experimental-use permit, registration, expanded use, or reregistration, invariably the Environmental Protection Agency (EPA) will ask for information on that chemical that involves Product Chemistry, Environmental Fate Chemistry, or Residue Chemistry. Thus, the Chemical Research Project was created within the Section of Chemical Development/Registration to address these needs. This project has the responsibility for collecting essential product chemistry data or information and for developing and conducting comprehensive research studies designed to support environmental fate or residue chemistry requirements. Project information and resource files are being developed so data requirements for EPA registration matters can be efficiently met either at the DWRC or in a commercial laboratory. In addition, project professionals are available for cooperative chemistry-related research projects, as either consultants or by direct participation. This project coordinates closely with the Section of Analytical Chemistry.

OBJECTIVES:

1. Establish the significance of hydrolysis as a route for degradation of strychnine.

2. Establish the significance of photolysis as a route for degradation of strychnine on soil.

3. Determine the extent of adsorption/desorption of strychnine in four different soils using batch equilibrium methodology.

4. Evaluate the degree of leaching of strychnine (parent compound and metabolites) that occurs in an "aged" soil under simulated rainfall conditions.

5. Determine the rate of disappearance of strychnine in soil held under aerobic conditions for an extended period.

6. If significant strychnine hydrolysis, photolysis, or aerobic soil metabolism occurs, identify the degradation products, reaction mechanism, and kinetics.

7. Conduct or arrange for analytical chemistry tests required under Subdivision D (Product Chemistry) of EPA's Pesticide Assessment Guidelines.

8. Develop a complete file for each of the Pesticide Assessment Guidelines and associated references for Product Chemistry, Environmental Fate Chemistry, and Residue Chemistry.

9. Monitor Quality Assurance/Quality Control matters related to analytical chemistry requirements.

ACCOMPLISHMENTS DURING FY-89:

Files encompassing Pesticide Assessment Guidelines have been developed on product chemistry, environmental fate, and residue chemistry data requirements for EPA registrations. References pertaining to product chemistry and the environmental fate studies discussed below have been obtained. A file has been developed for listing laboratories that routinely conduct required tests according to EPA protocol and Good Laboratory Practice Standards.

Project files have been developed on Quality Assurance/Quality Control and personnel have been involved in helping the DWRC to develop a strong QA/QC program. SOP's are being prepared for all appropriate equipment or methodology used within the project.

Project chemists have made numerous contacts with Environmental Fate Specialists at other private, university, or government laboratories concerning the above studies. Two trips were made to the Washington, D.C., area to (1) attend an environmental conference and visit APHIS facilities and (2) to visit senior scientists at the Environmental Chemistry Laboratory of USDA in Beltsville, MD, and EPA's Office of Pesticide Programs concerning the above-mentioned environmental fate studies.

The Washington, D.C., visit included discussions with the USDA Radiological Safety Officer concerning requirements for using radionuclides in environmental fate research, which will be a necessity for some of the upcoming registration requirements. All of the prerequisites have been met, and the necessary documentation submitted for obtaining a license and USDA approval.

The project cooperated with the Analytical Chemistry Section on Study Protocol QA-57 "Environmental Fate Study -Strychnine Alkaloid Hydrolysis". This project was initiated December 5, 1988 and completed May 24, 1989. The report was accepted by EPA without comment.

In another joint study, the Study Protocol QA-87 "Environmental Fate Study - Photodegradation of Strychnine Alkaloid on Soil" was written and submitted to EPA. EPA comments were received and the protocol was revised and returned to EPA with corrections. Special equipment has been purchased, a laboratory modified and test methodology developed. The 30-day experiment is scheduled for mid-January, 1990.

To meet Objectives 3 and 4, a third Study Protocol "Environmental Fate Study - Evaluation of the Persistence of Strychnine and its Metabolites in Various Soils" has been drafted. Equipment has been purchased and the laboratory prepared for work beginning in early FY90.

To meet Objective 5, literature work has been completed, contacts made and plans developed for drafting a fourth Study Protocol "Environmental Fate Study - Aerobic Degradation of Strychnine Alkaloid in Soil Under an

Optimum Temperature and Moisture Regime".

The following storage stability studies (Guideline 63-17) were initiated on strychnine products: 1.6% strychnine paste (registration numbers AZ810006, ID810047, and NM820019), 4.9% strychnine paste (ID870003), 0.4% strychnine-corn pigeon bait (56228-8), and strychnine technical (56228-16).

A storage stability study (Guideline 63-17) was initiated on Compound 1080 technical.

The Project prepared and submitted to the EPA an 8-volume Product Chemistry report on Compound 1080 Technical as follows: (1) administrative materials, (2) beginning materials and manufacturing process (Guideline 61-2), (3) formation of impurities (Guideline 61-3), (4) analytical material for verification of certified compound 1080 limits (Guideline 62-3), (5) melting point (Guideline 63-5), (6) bulk density (Guideline 63-7), (7) dissociation constant (Guideline 63-10), and (8) pH (Guideline 63-12).

Prior work commitments were completed and 3 manuscripts on the chemical/physical characteristics of the bird resistance found in a purple hulled sunflower variety were submitted to scientific journals. Two nutritional studies were conducted on Group II sorghums developed jointly by the Denver Wildlife Research Center and the University of Arkansas. Three lines of new hybrids have been released. The nutritional studies indicate that there are no differences in nutritional value for these three tannin-containing lines and nontannin control hybrids.

REPORTS AND PUBLICATIONS:

Bullard, Roger W., P. P. Woronecki, R. A. Dolbeer, and J. R. Mason 1989. Biochemical and Morphological Characteristics in Maturing Achenes from Purple-Hulled and Oilseed Sunflower Cultivars. J. Agric. Food Chem. 37:886-890.

Mason, J. R., R. A. Dolbeer, P. P. Woronecki, and R. W. Bullard 1989. Maturational and Varietal Influences on Sunflower Consumption by Red-Winged Blackbirds. J. Wildl. Manage. 53:841-846.

Mason, J. R., R. W. Bullard, R. A. Dolbeer, and P. P. Woronecki (in press). Red-Winged Blackbird (Agelius phoenicus L.) feeding Response to Oil and Anthocyanin Levels in Sunflower Meal. Crop Protection.

PROJECT TITLE: Chemical Development/Registration -- Non-predatory Mammals

PROJECT LEADER: Ray T. Sterner (303) 236-7868

INTRODUCTION:

This projects oversees and coordinates the USDA/APHIS commitment to maintain and develop registered chemicals and methods for the control of non-predatory mammal pests (e.g., pocket gophers, voles, ground squirrel) that decrease agricultural production. Novel research capable of facilitating this development effort is also undertaken.

Several pesticides such as strychnine and zinc phosphide are currently registered for the control of non-predatory mammals in the U.S. Additionally, new chemicals and methods which are capable of providing increased toxicological selectivity and effectiveness are needed. This project undertakes or contracts laboratory and field studies to collect the data required by the Environmental Protection Agency for re-registration of existing products, obtaining experimental use permits, or registration of new products. Data are collected in accordance with provisions of the Animal Welfare Act and Good Laboratory Practices Procedures.

OBJECTIVES:

1. Secure data to maintain registration of USDA/APHIS/ADC strychnine baits.

2. Secure data to maintain registration of USDA/APHIS/ADC zinc phosphide baits.

3. Compile the existent, approved methods for nuisance bat control; transfer this information to users.

4. Investigate potential changes in feeding patterns of select non-predatory mammals to EPA Challenge Bait following sub-lethal toxic dosing with strychnine and zinc phosphide.

ACCOMPLISHMENTS DURING FY-89:

The Denver Wildlife Research Center continued its coordination of the Strychnine Consortium, a group of private companies and public agencies who have contributed funds to reregister the technical strychnine product with EPA. Many of these data are being generated by the DWRC, including product chemistry and environmental fate. Other studies have been contracted to private laboratories and the DWRC is monitoring those contracts, developing analytical methods to support the contracts and analyzing samples as required. Studies completed by contract labs and submitted to EPA include: Fish Toxicity (Guideline 72-1), Invertebrate Toxicity (72-2), Acute Oral Toxicity - Rat (81-1), and Acute Dermal Toxicity Rabbit (81-2). Contract studies currently in progress include: Acute Avian Dietary (71-2), and Avian Reproduction (71-4). The Consortium Coordinator submitted Quarterly Progress Reports for the Strychnine Technical Product. Laboratory and field efficacy tests for registration of end-use strychnine products for

use against pocket gophers are being conducted by the Mammal Control Research Section. These data are being used by many members of the Consortium for registration of their end-use products.

A study was designed to evaluate potential crop residues of zinc phosphide in alfalfa, bean, wheat and potato crops. The research will be coordinated with staff at University of California -- Davis. Coordination will help meet EPA requirements for federal registration via appropriate crop selections and study locations (i.e., diverse climates).

Acceptance of some rodenticide baits is low and methods are needed to enhance bait palatability. A study was designed to evaluate the effect of strychnine and zinc phosphide bait formulations upon feeding patterns and bait consumption of various rodent species (e.g., pocket gophers, wild rats) was completed. This work will be undertaken in FY-90. The study will also assess aspects of the "EPA Challenge-bait Concept" and "bait-shyness behavior" of these species.

Compilation and preparation of available technical information for the control of nuisance bat problems within the U.S. was accomplished. Natural Resources Departments within each state were contacted for specific management information on indigenous species of bats. A selection of these articles, plus other significant publications dealing with bat management, endangered species, and public health issues were assembled and submitted to USDA/APHIS/ADC on June 23.

Analysis of data and preparation of 2 major reports related to Project Order 85PP5847 (Behavioral-physiological Effects of Red Phosphorus Smoke Inhalation on Two Wildlife Species) were completed.

REPORTS AND PUBLICATIONS:

Shumake, S.A., R.T. Sterner, B.E. Johns, and R.D. Thompson. 1989. Behavioral-physiological Effects of Red Phosphorus Smoke Inhalation on Two Wildlife Species. Task 2 Report (Effective Smoke Concentration Range-finding Determinations), Project Order No. 85PP5847, USDA/APHIS/S&T, Denver Wildlife Research Center: Denver, CO. 124 pp.

Sterner, R.T., S.A. Shumake, R.D. Thompson, and B.E. Johns. 1989. Behavioral physiological Effects of Red Phosphorus Smoke Inhalation on Two Wildlife Species. Task 3 Report (RP/BR Aerosol Effects upon the Spontaneous Activity, Startle Response, Pulmonary Function and Blood Chemistry/Hematology of Black-tailed Prairie Dogs (Cynomys ludovicianus) and Rock Doves (Columba livia), Project order 85PP5847, USDA/APHIS/S&T, Denver Wildlife Research Center: Denver, CO. 163 pp.

Fagerstone, K.A. 1989. The Federal Role in Urban Wildlife. Pest Management. 8 (8): 18.

Fagerstone, K.A. 1988. The annual cycle of Wyoming ground squirrels in Colorado. J. Mamm. 69 (4): 678-687.

PROJECT TITLE: International Vertebrate Pest Management Program--DWRC

PROJECT LEADER: Richard L. Bruggers, (303) 236-7850

INTRODUCTION:

In 1967, a cooperative program was established between the Administrator, U.S. Agency for International Development (AID), and the Secretary of the Interior delegating the U.S. Fish and Wildlife Service to conduct studies to reduce food losses caused by rats, bats, and noxious birds on a worldwide basis. This cooperative agreement was continued with the U.S. Department of Agriculture (USDA)/Animal and Plant Health Inspection Service (APHIS) with the transfer of Animal Damage Control (ADC) from USDI to USDA on December 19, 1985. In October 1988, the DWRC was further transferred from APHIS/ADC to APHIS/Science and Technology. Funds are provided to DWRC by USAID Missions, regional bureaus, and the USAID Bureau of Science and Technology to maintain a core group of international vertebrate pest specialists in the International Programs Research Section (IPRS) at the DWRC to implement the cooperative agreement. The program goal is to evaluate vertebrate pest situations in Asia, Latin America, and Africa and, when circumstances warrant, develop and implement environmentally acceptable methods to reduce vertebrate pest damage. International vertebrate pest management requires field visits, liaison, and ongoing interchange with pest control research and implementation organizations--both domestic and foreign. Goals are accomplished by in-country programs, TDY activities, supervisory and administrative functions from the DWRC, and problem-oriented research and training using expertise available at the DWRC.

OBJECTIVES:

1. Provide supervisory, administrative, and temporary duty (TDY) support for foreign field stations.

2. Conduct cooperative problem-oriented research at DWRC based upon field program priorities.

3. Develop and implement proposals for vertebrate pest management (VPM) programs worldwide.

4. Provide scientific support, on request, to AID/Washington, USAID Missions, and foreign governments by:

   a. Providing TDY technical assistance to developing countries.

   b. Arranging and providing training for foreign VPM technicians, administrators, and graduate students at DWRC.

   c. Coordinating VPM participation in international workshops, symposia, and conferences.

d. Responding to inquiries and foreign assistance requests to DWRC through correspondence, reports, publications, and cooperative research.

5. Work closely with international organizations, such as the Food and Agriculture Organization (FAO) of the United Nations, World Bank, Desert Locust Control Organization for East Africa (DLCO-EA), and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) on research problems of mutual interest.

6. Perform supervisory and program development functions at DWRC.

ACCOMPLISHMENTS DURING FY-89:

TDY Trips

During 1989, DWRC staff traveled to Asia, the Caribbean, Africa, and Europe at the request of USAID, USAID Missions, USAID/Washington, FAO, and foreign governments to assess vertebrate pest problems; to review, evaluate, and coordinate present and future research programs; to evaluate the impact on the environment and nontarget wildlife of locust control sprays; and to present seminars. TDY activities from DWRC are an important part of the project, and DWRC will continue to respond to such requests, as many types of short-term evaluations and cooperative studies with host-country scientists may be carried out expeditiously in this manner. Travel during FY-89 involved 341 person-days.

Mr. Keith LaVoie, Wildlife Biologist, IPRS, worked in Bhutan from September 26 to October 26, 1988, on a consultancy for FAO, to evaluate the impact of rodents in grain storage facilities. The degree of infestation ranged from moderate to intense and seemed to be related to the length of time a crop was stored, the physical condition of the storage structure, and the associated sanitation conditions. It was estimated that about 4% of the food stores were consumed by rodents and an additional 10-20% were contaminated. It appeared that the rodent problem could be alleviated in some of these situations through proper structural modifications and maintenance. Training of Ministry of Agriculture (MOA) personnel in sanitation and control methods would also reduce losses and health hazards from rodents.

Mr. Edward Knittle, Wildlife Biologist, Chemical Development/Registration Section, and Dr. Richard Dolbeer, Wildlife Biologist, Bird Control Research Section, completed a 6-week consultancy (October 10 to November 24) requested through the IPRS by USAID/Senegal as part of a team to monitor the general conditions under which pesticides were being stored, transported, handled, and applied during emergency locust control operations and to identify the impact of spraying locusts on nontarget wildlife in west Africa. These were DWRC's first consultancies to assess the impact of large-scale locust control operations on nontarget wildlife.

Mr. Lynwood Fiedler, Wildlife Biologist, IPRS, visited the Pakistan Vertebrate Pest Control Project (VPCP) between October 14 and November 8 to assist Project staff in implementing project activities for the remainder

of the current project (until June 1990), testing a method to evaluate rodent damage to groundnut, and evaluating training materials and subject matter for the master's training agenda.

Mr. Keith LaVoie traveled to Senegal between January 29 and February 21, 1989, to work with the MOA to gather data on chronic rodent infestation in crops in the Senegal River Valley. This activity involved identifying pest rodent species and quantifying damage. This was one of several consultancies planned for 1989 to Sahelian countries to better define the chronic rodent pest situation.

Dr. George Matschke, Wildlife Biologist, Mammal Control Research Section, traveled to Pakistan between February 3 and March 6 to assist the USAID/DWRC/VPCP in wild boar biology and control. Dr. Matschke assisted VPCP scientists and DWRC Project Leader (Mr. Joe Brooks) in designing a 4-year research proposal. In addition, he assisted and demonstrated techniques of live-trapping, chemical immobilization, and radiotracking, and began evaluating potential chemical toxicants as control methods.

Mr. Lynwood Fiedler traveled to the eastern Caribbean from February 8 to March 2 in the last of four consultancies sponsored by FAO to assist several islands to implement rodent pest management to reduce food losses. The islands receiving this technical assistance include Barbados, St. Kitts, Antigua, Dominica, St. Lucia, St. Vincent, and Grenada.

Dr. Richard Bruggers, Chief, IPRS, traveled to Bangladesh and Pakistan from March 29 to April 15 to assist the Project Leader in Dhaka, Bangladesh (Dr. Michael Jaeger) in preparing for an upcoming external review of the Vertebrate Pest Project and in planning the direction of activities for the remainder of the project. Dr. Bruggers also assisted the DWRC Project Leader in Pakistan in planning project activities through June 1990 and investigating the feasibility of various options for DWRC assistance to the Government of Pakistan (GOP) beyond June 1990.

Dr. James Keith, Wildlife Biologist, IPRS, consulted in Morocco from March 31 to April 9 at the request of USAID/Rabat to initiate a project to evaluate the direct (toxic) effects of locust control sprays of malathion and fenitrothion on the environment and nontarget wildlife. This project will involve cooperative studies with the Government of Morocco, the Peace Corps, and USAID. A proposal for FY-90 was developed which consists of three phases--training of Moroccan scientists, gathering of baseline data, and finally, the experimental application and evaluation of insecticides to study areas.

The necessary documents were finalized by USAID to establish a new USAID/DWRC field station in Chad, Africa. This field station will begin in FY-90 and will be involved in setting up a rodent population monitoring system, assessing acute and chronic rodent damage, evaluating and field testing bait delivery systems and providing the necessary training to Chadian scientists to eventually implement their own rodent management program. Mr. Lynwood Fiedler visited Chad, from April 23 to May 12 to determine the logistic considerations and requirements for establishing this rodent field station. Discussions were held with personnel of AID/N'Djamena and Chad

MOA regarding a number of points related to personal (housing, vehicle recreation, consumables, etc.) and work-related (office, vehicle, contract logistical support services, etc.) needs.

Dr. James Keith also was in Senegal from June 27 to September 3 and again from September 11 to October 13 to conduct studies of the impact on birds of the use of insecticides to control African migratory locusts and grasshoppers. These studies were conducted cooperatively by FAO, France, the Netherlands, Senegal, the United Kingdom, and the United States. The study team included aquatic biologists, ecologists, terrestrial entomologists, ichthyologists, ornithologists, a pesticide application specialist, an expert in soil micro-organisms, and toxicologists. The extent of ecological and biological processes covered by the study team was extensive, and results should provide a good basic assessment of the kinds of environmental effects that result from applications of fenitrothion and chlorpyrifos.

Mr. Lynwood Fiedler was in Bangladesh from September 24 to October 18, 1989, to assist the Government of Bangladesh and the USAID/DWRC-supported Vertebrate Pest Section and DWRC Project Leader in implementing a large-scale pilot demonstration of rodent control in rice. This rodent control demonstration was conducted in two 48-km^2 sites and tested the field efficacy and farmer acceptance of two control techniques and a rodent management strategy.

Supportive Research Activities

In 1988, a DWRC consultancy supported by FAO enabled an evaluation of the environmental effects of fenthion used for quelea control in Kenya. The team organized to conduct this work consisted of two IPRS biologists, Analytical Chemistry Section chemists, the FAO quelea project leader in Nairobi, and Mr. John Ngondi, a senior pest control specialist in the Kenya MOA. The fieldwork was conducted in Kenya during August 1988. Fenthion residue analyses in samples were begun in 1989 and are continuing, and Mr. Ngondi worked at DWRC from March 13 to April 3, 1989, to begin preparation of a manuscript reporting results of the research.

Studies have continued toward developing a low-cost, nonedible carrier for rodenticides that can be used in both rat burrows and in storage structures. The belief is that rodents will ingest the toxicant when attempting to remove the carrier while grooming. This may eliminate some of the current problems with ingested baits such as bait novelty, preferences, and shyness.

The DWRC Analytical Chemistry Section completed an assay of over 100 samples of the rodenticide zinc phosphide, which was purchased from local markets in Bangladesh. Twenty of 21 samples were <80% pure, with 15 of 21 samples having less than 40% a.i. These results may partially explain why farmers no longer purchase the material for rodent control in Bangladesh.

Participation in Meetings, Conferences, Seminars

Dr. James Keith attended the 1st Annual Conference for the Society for Ecological Restoration and Management in Oakland, California, between January 16 and 20, 1989. The purpose of the Society is to encourage the development of ecological restoration and management as a scientific discipline and a strategy for environmental conservation.

Messrs. Lynwood Fiedler and Keith LaVoie attended the 9th Great Plains Wildlife Damage Control Workshop in Fort Collins on April 19.

Dr. James Keith participated in the 1989 Desert Locust Grasshopper Workshop in Dakar, Senegal, between February 6 and 9. The workshop discussed the current locust situation in the Sudan/Sahelian countries, the country action plans for 1989, technical aspects of locust control, and environmental issues. Participants included representatives from the USAID Missions, Office of Foreign Disaster Assistance, FAO, and international locust control experts. Following this meeting, Dr. Keith was at FAO headquarters, Rome, between February 13 and 17 to represent USAID at a Working Group Session to design an FAO/Dutch/British/American environmental assessment project. DWRC/IPRS involvement in the development of this multination research effort was from the standpoint of trying to minimize the impact of chemical control operations (e.g., locusts and perhaps birds and rodents) on the environment and nontarget wildlife.

Dr. Keith was invited to speak at Ohio State University on May 5 on "The history of DDT, its uses, and environmental effects." His talk was part of a seminar series on "Technology and the Environment" that was organized by Dr. Tony Peterle. Invited speakers from throughout the United States and Canada participated in these seminars to help inform students and the general public about the environmental limits that exist to the use of technology.

Training

IPRS continued collaboration with the Department of Wildlife and Fisheries of Colorado State University (CSU), Fort Collins, in international vertebrate pest management training. DWRC biologists continued to teach classes in the biennial VPM course during the fall semester. Assistance was provided to Mr. Md. Sayed Ahmed, an International Rice Research Institute-sponsored Ph.D. candidate, in developing a research proposal to develop a toxicant delivery system utilizing rodent grooming behavior applicable to *Bandicota bengalensis*, for use by Bangladesh farmers. Agreement was reached to permit Messrs. Yousuf Mian and Ejaz Ahmad, DWRC project counterparts at the Bangladesh Agricultural Research Institute and the National Agricultural Research Centre in Pakistan, respectively, to formally apply for admittance into Ph.D. programs.

DWRC and CSU completed on August 25 their 2nd International Short Course in Vertebrate Pest Problems and Solutions in Developing Countries. Twelve individuals from the countries of Bangladesh, Guinea-Bissau, Indonesia, Japan, Malawi, Mexico, Philippines, and Uganda attended this 2-week course, which was organized by IPRS. About 50 individuals from the United States

(including 30 DWRC staff members), Argentina, Australia, England, Hungary, and Uruguay presented information. Topics included basic field and laboratory research techniques; pre- and postharvest pest problem identification; field demonstrations of control techniques and crop protection methods; specialized marking, monitoring and surveillance techniques; library information attainment, exchange, and retrieval; computer applications and statistical considerations; and pest management strategies.

Mr. Rajat Pandit, Scientific Officer from the Vertebrate Pest Section, Bangladesh Agricultural Research Institute, Joydebpur, Bangladesh, successfully completed a 6-week predator pest research consultation with DWRC. Mr. Pandit spent the period of July 31 to August 12 at the DWRC Predator Research Field Station in Logan, Utah, where he worked with Project Leader Dr. Fred Knowlton. Between August 28 and September 8, Mr. Pandit worked at the DWRC headquarters in Denver where he was involved in a variety of predator-related activities, including making sonograms of jackal calls, collecting over 200 predator publications, setting traps and snares at a Colorado ranch where sheep were being killed, discussing research proposals, and acquiring experience using a bibliographic reference computer program, Procite.

A week of training in computer use was provided to the Bangladesh Project Leader at DWRC in conjunction with his home leave. Programs were develope for establishing data sets on the project computer soon to be purchased, and graphics were reproduced by computer for use in project reports, seminars, and publications.

Visitors

Dr. David Bathrick, Chief, Office of Agriculture, Bureau of Science and Technology (S&T)/AID, visited DWRC in October 1988 for orientation on the DWRC research capabilities and to discuss continued involvement of IPRS in the AID/S&T Bureau mandates.

During the week of March 6, 1989, IPRS hosted an external review team comprised of Mr. Allen Hankins, USAID, Asia Bureau, and Dr. William Jackson, Professor Emeritus from Bowling Green State University, Bowling Green, Ohio. The purpose of this review was to conduct a mid-term technical and performance evaluation of the implementation of the Vertebrate Pest Management Systems Participating Agency Service Agreement between USAID, S&T, USDA, and DWRC. The review team was extremely supportive of DWRC implementation of this AID-funded program.

On June 18 and 19, IPRS again hosted an external Review Team consisting of Drs. William Jackson and Paul Marko, Associate in Rural Development, Burlington, Vermont. The purpose of this review was to evaluate DWRC technical assistance and backstopping support to the USAID/DWRC vertebrate pest field station in Bangladesh. This second review team was also very positive about DWRC backstopping support to the Bangladesh project and to the entire project in general.

REPORTS AND PUBLICATIONS:

Bruggers, R. L., M. M. Jaeger, J. O. Keith, P. L. Hegdal, J. B. Bourassa, A. A. Latigo, and J. N. Gillis. 1989. Impact of fenthion on nontarget birds during quelea control in Kenya. Wildl. Soc. Bull. 17:149-160.

Dolbeer, R. A., L. A. Fiedler, and H. Rasheed. 1988. Management of fruit bat and rat populations in the Maldive Islands, Indian Ocean. Proc. 13th Vertebr. Pest Conf., Monterey, California, 13:112-118.

Fiedler, L. A. 1988. Rodent pest problems and management in eastern Africa. FAO Plant Prot. Bull. 36(3):125-134.

Fiedler, L. A., M. W. Fall, R. L. Bruggers, and J. W. De Grazio. In press. Rodent and bird problems in agriculture and their management in developing countries. Proc. Vertebr. Pests and Ecology, 11th International Plant Protection Congress, Manila, October 5-9, 1987.

LaVoie, G. K., G. C. Mitchell, and M. S. Bornstein. In press. Contamination and consumption of stored wheat by a closed population of Mus musculus. Proc. 11th International Congress of Plant Protection, Manila, Philippines, Oct. 5-9, 1987.

Mitchell, G. C., F. L. Powe, M. L. Seiler, and H. N. Mitchell. 1989. An annotated bibliography on rodent research in Latin America, 1960-1985. FAO Plant Production and Protection Paper 98, FAO, Rome. 363 pp.

Soliman, S. 1988. Developing a tracking-edible gel/toxicant delivery system for control of Rattus norvegicus and Mus musculus. Proc. Egypt. Acad. Sci. 38:179-185.

Project Proposals

LaVoie, G. K. 1988. Project document draft proposal for rodent control in Food Corporation of Bhutan storage facilities. Submitted to FAO, Rome. 5 pp.

Keith, J. O. 1989. Research proposal--ecological effects of some insecticides used for locust control in Africa. Submitted to USAID/Africa Bureau for approval. 6 pp.

Keith J. O. 1989. Research proposal--training, research and monitoring to evaluate the effects of locust insecticides on the environment. Submitted to USAID/Rabat in Morocco. 4 pp.

Trip Reports

LaVoie, G. K. 1988. Trip Report--Bhutan. 14 pp. and 2 appendices.

Knittle, C. E. 1988. Trip Report--Senegal. 4 pp. and 1 appendix.

Fiedler, L. A. 1988. Project planning, groundnut rodent damage assessment, and wild boar research. Trip Report--Pakistan. 8 pp. and 2 appendices.

Dolbeer, R. A. 1988. Environmental assessment for U.S. Locust Control Program--Senegal. Trip Report--Senegal. 16 pp.

LaVoie, G. K. 1989. Trip Report--Senegal and Mauritania. 16 pp.

Matschke, G. H. 1989. Project planning and wild boar research. Trip Report--Pakistan. 14 pp.

Keith, J. O. 1989. Locust/Grasshopper Management Workshop and planning meeting studies of locust insecticide effects on the environment. Trip Report--Senegal and Italy. 5 pp. and 4 attachments.

Fiedler, L. A. 1989. Prevention of food losses through rodent control. Trip Report--Caribbean. 15 pp. and 2 appendices.

Bruggers, R. L. 1989. Trip Report--Bangladesh and Pakistan. 10 pp.

Keith, J. O. 1989. Trip Report--Morocco. 4 pp. and 2 attachments.

Fiedler, L. A. 1989. Planning for the establishment of the proposed rodent control project in Chad. Trip Report--Chad. 9 pp. and 4 appendices.

Keith, J. O. 1989. Environmental effects of insecticides used in locust control. Trip Report No. 1--Senegal. 4 pp. and 7 attachments.

Keith, J. O. 1989. Environmental effects of insecticides used in locust control. Trip Report No. 2--Senegal. 3 pp. and 4 attachments.

Fiedler, L. A. 1989. Trip Report--Bangladesh. 6 pp.

NOTE: Trip reports are on file at the International Programs Research Section, DWRC.

PROJECT TITLE: International Vertebrate Pest Management Program--Bangladesh

PROJECT LEADER: Michael M. Jaeger, USAID/Dhaka, Via Air Pouch, Agency for International Development, Washington, D.C. 20520-6120
Telephone: 711-011-880-2-604667

INTRODUCTION:

The vertebrate pest control program in Bangladesh was instituted in November 1978. A Vertebrate Pest Section (VPS) was established within the Entomology Division of the Bangladesh Agricultural Research Institute (BARI) at Joydebpur, 32 km north of Dhaka. USAID/DWRC activities from the onset involved assisting in organizing the VPS, purchasing commodities, developing the laboratory, and implementing research activities. A combination laboratory-office building was completed in July 1979; several outdoor animal facilities have since been added. To date, two Ph.D. scientists and three M.S. scientists have been trained and are working with the Project in a wide variety of laboratory and field research activities and have produced numerous technical reports and publications. The Project has established and is maintaining cooperative ties with the Bangladesh Rice Research Institute (BRRI), the Ministry of Agriculture (MOA), Department of Agriculture Extension (DAE), and other organizations. Backstop support and technical assistance in various aspects of laboratory and field studies are provided by the DWRC. The VPS is developing practical control techniques and strategies, and staff are working with extension personnel throughout the country to implement these strategies. DWRC/IPRS involvement in vertebrate pest research and management activities is funded into October 1990. The present Project Leader, Dr. Michael Jaeger, arrived in October 1986, succeeding Mr. Joe Brooks (1981-1985) and Mr. Richard Poché (December 1978-1980).

The objectives of this Project are to:

1. Increase the available food supply.

2. Develop management strategies for important agricultural situations and household stored food.

3. Appraise the nature and magnitude of losses caused primarily by rodents and jackals, and develop, if appropriate, environmentally responsible methods to reduce these losses.

4. Coordinate activities with other organizations to maximize results.

5. Institutionalize in-country research and management programs.

ACCOMPLISHMENTS DURING FY-89:

The work plan developed in 1986 continued to be implemented. Baseline data were collected on preharvest rat damage to ripening wheat and rice, post-harvest rodent damage in grain stores in farmers' houses, and jackal movements and damage potential. This work is being conducted in two large

study areas that represent two ecological zones (wet plains and dry lands) where cereal production is concentrated. The different pest problems are being studied in each area each month to evaluate their interrelationship and determine opportunities for integrated pest management.

Preharvest Rodent Damage

A 15-month study describing preharvest rodent damage at two 4,800-ha study sites was completed. The study sites represented the transplanted aman rice agroecosystem and the broadcast, deepwater aman rice system. Preliminary results have shown that the number of rat burrows per hectare in both study sites peaked in November/December at the end of the aman rice crop. A second smaller peak occurred in March coincident with wheat crop maturation. Pulse and mustard fields were used by the lesser bandicoot rat (*Bandicota bengalensis*) until adjacent wheat fields matured and became more attractive. These results were used to model when and where rat control would be most cost effective in relation to the four major grain growing seasons in Bangladesh (aman rice, boro rice, wheat, and aus rice). It was concluded that control should focus on the aman crop.

A field study was also initiated to compare two rodent control strategies: early-flood, deepwater aman rice (July-August) baiting on high ground *vs* late-flood (September-October) baiting on high ground. A 4,800-ha site was chosen at Manikganj, and monthly data collection was begun in May. The early-flood treatment comparing fumigation with Phostoxin^R (aluminum phosphide) with toxic bait injection (5-g wax blocks containing brodifacoum) was applied in early August and directed at rat burrow systems. September flooding destroyed the entire rice crop at this site, making comparison with a later treatment meaningless. However, post-flood burrow counts showed a 56% reduction from the burrow density at the time of treatment. This suggests that flooding can substantially reduce rat numbers and that control implemented after peak flooding might be more efficient. The late-flood treatment was moved to an alternate site at Noakhali and applied in late October, when the rice crop in that area was flowering. Burrow counts at harvest in mid-December showed that the Phostoxin treatment had reduced burrow density. Results from the brodifacoum treatment were inconclusive; however, rats did remove toxic baits placed in freshly excavated tunnels, even in the presence of mature rice upon which they were feeding.

To support these field observations, studies were initiated in the newly modified enclosures at the Vertebrate Pest Control Laboratory (VPCL), Joydebpur, to determine the numbers of *B. bengalensis* per burrow system, the amount of rice panicles removed per rat per day, the efficacy of Phostoxin as a burrow fumigant, and the acceptance of baits in the presence of a food source. Preliminary results suggest a single adult rat per burrow, an average of 57 g of rice removed per rat per night, and about 75% success in killing rats in burrows with a single tablet of Phostoxin.

Postharvest Rodent Damage

A long-term study of losses by rodents to stored grain, concomitant with the preharvest study, was completed in the same two ecological zones using the same sampling design. Like the preharvest study, the objective was to

describe the spatial and temporal pattern of postharvest losses to rodents through a model whose components include the seasonal pattern of grain storage, the numbers and spatial distribution of farmsteads, and the seasonal fluctuations in the numbers and types of rodents. At both sites, the seasonal trends in rodent numbers and stored grain were bimodal and overlapped, peaking at the time of the aman rice harvest in December-January and after the boro-aus rice harvest in July-August when flooding was widespread. No additional field data were collected because the principal investigator departed Bangladesh in January 1989 to begin postgraduate training that emphasizes modeling the problem to predict those agroecological situations where damage is greatest, to estimate losses, and to recommend when and where control can be the most cost effective.

The burrowing behavior of the principal rat pest of preharvest cereals (B. bengalensis) was studied in outdoor enclosures at the VPCL facility at BARI/Joydebpur. The objectives were to determine if B. bengalensis uses burrow systems throughout the year and to determine the average number of adults occupying each burrow system. The test enclosure was divided into six separate compartments, and combinations of adults were released into randomly assigned compartments for a period of 2 weeks. The number of burrows dug equaled the number of rats present, suggesting that burrow density is a good measure of the number of adult B. bengalensis. Similar work will be done with the other burrowing species, Bandicota indica and Nesokia indica. The daily numbers of panicles of rice cut and the final amount of panicles stored in underground chambers averaged 21.8 (± 1.28 S.E.) and 27.2 (± 1.08) g/day, respectively. This represents an average daily loss of 63.7 g dry weight of rice seed at an average seed weight of 1.3 g/panicle.

Fumigation of rat burrow systems with Phostoxin tablets appeared to be a cost effective means of control during the 1988 aman rice season. This method was evaluated again during the 1989 wheat season, when drier soil conditions prevailed, and compared with baiting of burrow systems with zinc phosphide (Zn_3P_2) bait cakes. This was a large-scale field test in a principally wheat growing area near Kustia. A total of four 8- x 1-km^2 blocks were randomly selected, divided into 25-ha quadrats, two of which were randomly selected as controls and two selected as treatments. A single tablet of Phostoxin or a single cake of zinc phosphide was sealed into all active rat burrow systems found in the 25-ha test plots during the booting stage of wheat. At the time of treatment, there were no significant differences between treatment and control areas in the density of burrow systems. At harvest, however, there were significantly fewer burrow systems in both of the treatment quadrats than in the controls ($F < 0.001$), and in the Phostoxin quadrats compared to the zinc phosphide quadrats ($F < 0.001$). The cost:benefit ratio, however, was better for zinc phosphide than Phostoxin.

Poor quality of zinc phosphide available in the markets is believed to be a major reason why farmers are reluctant to purchase this product for rodent control. This is marketed in small packets containing 1-5 g of technical grade concentrate which are prepared by the users into 1-g bait cakes of 2-3% zinc phosphide. This concentration and dosage of the a.i. are critical to its effectiveness. In order to evaluate the quality of the

locally marketed product, five packets of each of 21 different brands were purchased from local markets in several different areas including Dhaka, Comilla, Tangail, and Joydebpur and sent to DWRC for assay by the Analytical Chemistry Section. Twenty of 21 brands had purity <80% and 15 of the 21 had purity <40%. These results suggest that much of the Zn_3P_2 that is on the market is degraded, diluted, or contains no active ingredient at all.

The anticoagulant rodenticide, brodifacoum, will shortly be registered for use in Bangladesh. Low application rates were evaluated during the wheat season (January-March) in a field trial at Manikganj. A single application coinciding with the booting stage of the wheat was made by inserting either one or two 5-g Klerat[R] bait blocks into all of the active rat burrow systems found in 25-ha test plots, giving application rates of 0.015 and 0.025 kg/ha for the 5-g and 10-g treatments, respectively. The overall density of rat burrow systems in the study area at the time of this trial seemed to be unseasonally low, probably due to the high mortality of burrowing rats that was associated with the very extensive flooding the previous September. There was, however, no significant difference in the number of rat burrow systems in treated and control areas from the time of treatment until harvest. Klerat was provided by ICI Agrochemicals, United Kingdom, as 5-g wax blocks with 0.005% a.i).

Jackal Predation

Preliminary investigation of the feeding habits of jackals in Bangladesh suggests that their benefit as a rodent predator may outweigh their damage to poultry and crops. Research began in 1988 to develop a large-scale and long-term study to better understand the impact of predators, primarily jackals, on the major rodent pest species, and to compare the agricultural damage caused by both rodents and jackals. Work has concentrated on mapping the study site, developing a technique to census jackals, and determining the average weight in rats a jackal might reasonably consume per day. If predation is a very important biological check on rat populations in Bangladesh, mismanagement of predators might substantially worsen the rat problem.

A 25-km^2 study area was established near Sripur for a long-term study of the impact of predators, principally jackals, on agriculture in Bangladesh. A technique to census jackals was evaluated using taped jackal calls played through a speaker system mounted on top of a vehicle, and the number of different jackals responding was recorded. Tests were conducted one night a week over a 3-month period from April through June. Calls were broadcast from within 9-12 randomly selected 1-km^2 blocks during the night from 2100 to 0600 hours. Two types of responses were found: vocalizing and/or approaching the vehicle within the range of a high-powered search light. Results showed that jackal responses were greatest between midnight and 0300 hours. Preliminary testing suggests that the maximum distance from which a response could be heard was 500 m and that, therefore, the maximum area sampled during each trial was 0.78 km^2. Based on this, the average number of jackals responding/km^2 during the 40 trials from midnight to 0300 hours was 2.5 animals. This censusing technique looks promising and worth further testing.

The consumption of rats by caged jackals is being studied to determine the number of rats eaten by a jackal in a day, and the time and number of jackal scats in which a single rat will be passed. This information is necessary for modeling the impact of jackals on both rats and poultry. Preliminary findings are that caged animals consume an average of roughly 500 g/day or the equivalent of two B. bengalensis. An average of a single scat was voided per day, and a rat would be passed in a single scat the day after consumption.

Training and Future Research

A 1-day workshop was convened by the Bangladesh Agricultural Research Council (BARC) to review the current status of vertebrate pest research in Bangladesh. Presentations were made by the VPS professional staff and the DWRC Project Adviser who, in addition, edited the proceedings. One outcome of this meeting was the formation of a national committee to recommend vertebrate pest research needs. This committee includes the DWRC Project Adviser and a VPS representative.

Project scientists participated in or were given a variety of training opportunities. Mr. Yousuf Mian began his Ph.D. program at Colorado State University (CSU). His training will emphasize statistics, modeling, and computer use in describing and evaluating vertebrate pest problems. Mr. Santosh Sarkar, DAE, continued his Ph.D. research (Dhaka University) under the direction of the DWRC Project Leader. Mr. Sayed Ahmed, BRRI, continued his Ph.D. research in vertebrate pest management at CSU. Dr. Parvin Sultana, Mr. Emdadul Haque, and Mr. Rajat Pandit received basic instruction in DOS and word processing from Beximco Computers in Dhaka. Dr. Parvin Sultana and the Project Leader lectured in the Farming Systems Training Course given by CHECCHI.

A research proposal entitled, "Developing a strategy for extending rodent control technology to the Bangladeshi farmer" was developed for conducting a large-scale field study between September and December 1989. This research will evaluate both control methods and farmer acceptance of a recommended control strategy. This research activity will be conducted in cooperation with BARC, DAE, Farming Systems Research (FSR)/BARI, and CHECCHI.

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PROJECT TITLE: International Vertebrate Pest Management Program--Pakistan

PROJECT LEADER: Joe E. Brooks, USAID/Islamabad, PSC Box 8,
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INTRODUCTION:

The Pakistan Project was initiated in late 1985 under a mission-sponsored agreement with USAID. The DWRC has provided an in-country Project Leader to direct efforts to increase human food supplies, determine if there is a problem of vertebrate losses of stored grains, develop indigenous capabilities of meeting vertebrate pest problems using integrated pest management methods, and institutionalize in-country research programs. Scientists and facilities of the DWRC provide support for the vertebrate pest control efforts in Pakistan on a reimbursement basis. Funding support for this Project currently ends in June 1990, at which time the Project Leader, Mr. Joe Brooks, is scheduled to return to DWRC. A funding mechanism and technical assistance options to continue DWRC involvement beyond that time are being explored.

OBJECTIVES:

1. Increase the available food supply.

2. Appraise the nature and magnitude of stored grain losses and agricultural losses caused by vertebrate pests.

3. Develop integrated control programs for important vertebrate pest problems in agriculture and grain storage facilities.

4. Coordinate activities with other international organizations to maximize results.

5. Develop indigenous capabilities.

6. Institutionalize in-country research and control programs.

ACCOMPLISHMENTS DURING FY-89:

A large-scale control demonstration of rodent control in wheat and rice was initiated in January 1989. It will be conducted through at least three crop cycles or until May 1990. Readymade rodenticidal baits were made available to farmers at a nominal cost. A multimedia awareness and motivational campaign for farmers, employing posters, handbills, video cassettes, personal contact, and farmers' training sessions, was held during the first wheat season. Wheat damage by April 1989 was minimal (0.61%); consequently very few farmers implemented rodent control. By May 1989, just at harvest, damage had increased to 3.27%, due to an influx of rats from harvested sugarcane fields.

A post-season evaluation of the multimedia awareness and motivational campaign disclosed that one-third of the farmers were aware of the ready-made baits and, of these, 65% had learned of them through the posters. The

rest learned of the ready-made baits through handbills, personal contact, or while at the Crop Maximization Program (CMP) workshop or the Union Council office. Eleven (10%) of the farmers had used ready-made baits, and 90% reported they were effective. More baits would have been used had the rodent damage to wheat been more severe.

New posters and handbills were prepared in August for the rice season control demonstration. A video tape on rodent control in rice was made and shown to farmers throughout the control demonstration area. Again, however, rodent damage was little, averaging only 0.28% of cut tillers in late September, only 4 weeks before harvest. This was attributed to heavy rains in late July which flooded the entire area for more than a week, probably killing many rats in the fields.

Wild Boar Biology and Control

A cooperative research study on the biology and control of wild boar in agricultural areas was undertaken with the University of Agriculture, Faisalabad. The objectives of the study are to describe the biology and behavior of wild boar and to develop simple, safe, effective, and inexpensive methods of protecting crops from their damage. During the period March 1987 to September 1989, a total of 406 wild boar was collected.

Animals were aged by tooth eruption patterns and wear on the third molar. Separating the sample into age groups revealed that half were 12 months or less, one-quarter were 12-24 months old, and the remainder were 3-6 years old. It appears there is fairly rapid population turnover per year.

Wild boar were found to breed mainly in the months of December to March, with the majority of young born between April and August. In both 1988 and 1989, there was evidence of a very small breeding effort in the late monsoon, with a few pregnant animals seen in August and September.

Males and females were found to be sexually mature at 7 months and young-of-the-year females made a significant contribution (7 out of 30 pregnancies) to the breeding effort in 1988. In 1989, only 2 out of 19 pregnancies were attributable to young-of-the-year females. Litter size for all females averaged 5.8 ± 2.3 but was greater for older females (>24 months = 6.6 ± 2.2) compared with younger females (<24 months = 4.8 ± 2.2).

Males grew to significantly longer body lengths and heavier body weights than did females. The heaviest male weighed 135 kg; the heaviest female, 85 kg. Females predominated in the collection, 226 to 180, a 1:0.8 sex ratio.

The critical damage period for wild boar in the cropland areas appears to be May through July, after wheat is harvested but before maize, sorghum, and sugarcane are tall enough to provide food and cover. At this time, the wild boar usually retreat to dense growths of marshy grasses or mesquite/acacia thickets. However, from a management strategy, it may be more appropriate to reduce their numbers during the major breeding season, i.e., during the period December through March. Field evaluations of

candidate toxicants, baits, and bait delivery systems are being carried out with this strategy in mind.

Preliminary field trials to evaluate the effectiveness of anticoagulant baits for controlling wild boar were completed in April 1989. Wild boar had been causing heavy damage to wheat fields in the Punjab Barani Livestock Research Institute near Fateh Jhang. Anticoagulants, mixed with sugar in wheat dough balls, seem to be very well accepted by boars. However, trials to use hog feeders as a delivery mechanism that would permit only hogs to remove baits were unsuccessful. While these hog feeders effectively excluded jackals and porcupines, wild boar would not use them. Innovative baiting methods will be needed if wild boar control is eventually deemed necessary.

Institutionalization of Vertebrate Pest Management In-Country

The Vertebrate Pest Management (VPM) Section was included in the National Agricultural Research Centre (NARC) Research Master Plan, which will soon be formally accepted and printed. This is a main step toward institutionalization of a vertebrate pest research and management activity in Pakistan.

A VPM Subunit of the Pest Management Research Institute (PMRI), Karachi, was established at NARC in July. Mr. Aziz Khan, Principal Scientific Officer, was transferred to NARC along with four other staff members. This is another step forward in institutionalization of VPM at NARC and in-country.

Cooperative Research with Universities

Long-term studies in the reproductive ecology and food habits of lesser bandicoot rats (*Bandicota bengalensis*) on the NARC campus are continuing. During the past 12-month period, 290 rats have been analyzed for reproductive biology, food habits, and hormone assays. The most unexpected results have been related to the breeding periods, with pregnant females being found only during July-August 1988 and April-May 1989. The apparent lack of breeding activity during the other 8 months is still unexplained. Pregnant females again showed up in samples from July through September 1989.

Food habits were analyzed from the stomach samples taken from 96 rats during the year. Most rats were trapped from wheat fields and fallow wheat fields following harvest. A few were trapped in groundnut and rice fields and in grassy areas. Three foods predominated in the monthly samples: (1) the leaves, stems, panicles, and grains of wheat; (2) seeds, flowers, and rhizomes of *Desmostachya bipinnata* and (3) *Cynodon dactylon*. Wheat consumption started in November and continued through August. There was an inverse relationship between the consumption of wheat and *Desmostachya* during the months of November to March. By April, wheat constituted more than 95% of the dietary intake. This continued through June. *Desmostachya* was seen in the stomachs during 9 of the 12 months; *Cynodon* occurred in 5 months beginning in July, peaking in August, and finished by November. Groundnut and rice appeared in September and October. Minor dietary items were *Cyperus rotundus* (1.2%), *Convolvulus* sp. (0.4%) and insects (0.2%).

This work is being conducted by Mr. Iftikhar Hussain in partial fulfillment of a M.Phil. degree at Quaid-i-Azam University.

Several studies of vertebrate pest problems were initiated or completed under a cooperative research agreement between the Vertebrate Pest Control Project (VPCP) and the University of Agriculture, Faisalabad. Dr. Mirza Beg coordinates this research. Research topics include distribution and dynamics of rats and mice populations under different cropping practices, rice-wheat-fodder system; distribution and dynamics of rat and mice populations under conditions of different cropping practices, wheat-sugarcane-fodder system; breeding success in the rose-ringed parakeet in some subhabitats of the agroecosystem; distribution, ecology and taxonomic status of mice inhabiting the croplands and scrublands of Central Punjab; biology and ecology of short-tailed mole rat (Nesokia indica); and distribution, density and economic importance of house rats in villages and farm houses.

Mr. Lynwood Fiedler, IPRS, DWRC, visited the Project between October 14 and November 8, 1988, to assist Project staff in implementing project activities for the remainder of the current project (until June 1990), testing a method to evaluate rodent damage to groundnut, and evaluating training materials and subject matter for the master's training agenda.

Dr. George Matschke, Wildlife Biologist, Mammal Control Research Section, DWRC, was in Pakistan from February 3 to March 6, 1989, to assist the Project staff in developing methods of trapping and netting wild boar for eventual use in radiotelemetry studies, evaluating current wild boar research and developing future research plans, and establishing a piggery in which to study the growth and behavior of wild boar. The piggery was established in April and contains an observation blind from which boars can be photographed.

Dr. Richard Bruggers, Chief, IPRS, and Ms. Linda Raver, USDA/Office of International Cooperation and Development (OICD), Washington, were in Pakistan April 8-14 to assist the Project Leader and Ms. Raver in preparing a Concepts paper and budgets for a follow-on technical assistance project to begin in July 1990.

Training, Outreach, and Extension

The VPCP is cooperating with the Kansas State University Storage Technology Development and Transfer (STDT) Project in giving master's training and operational staff training to Pakistan Agricultural Storage and Services Corporation and Provincial Food Department personnel. The STDT Project has prepared a training manual in both English and Urdu. A part of this manual incorporates the vertebrate pest control material previously prepared. The revised VPC reference manual and the Urdu language version of the grain storage handbook have been printed, and 500 copies of the handbook and 100 copies of the reference manual have been supplied to the STDT Project.

In-service training was provided to an FAO trainee (Mr. Oluka James from Uganda) in April and May and involved 28 man-days. Mr. James assisted in fieldwork at Gujrat in wheat surveys and was given training in a variety of other VPM techniques.

During FY-89, the Project staff received training in "M-STAT," "Lotus 1-2-3," "The use of photography in agricultural research," "The use of videography in agricultural research," "Research management," and "Integrated pest management in grain storage."

A 2-week training course in VPM was presented to 14 participants (including three FAO-sponsored participants--two from Syria and one from Uganda). The training course was held at the NARC training institute from March 18 to 30, 1989. Practical demonstrations in both lecture sessions and the field were emphasized.

The Project staff also provided training in many aspects of VPM to over 480 individuals including farmers, high school students, agricultural officers, and extension officers on 16 different occasions. In addition, training and training materials including reference manuals, slide sets, video cassettes, and posters related to grain storage management were provided to Master Trainers at the STDT Project Training Center. Since completion of their training in January 1989, these Master Trainers have provided similar training to 396 other participants.

Mr. Brooks presented three lectures at the FAO/Pakistan Agricultural Research Council (PARC) master's training in "Integrated Pest Management in Grain Storage" to 22 participants on May 31. These lectures were on "Biology and ecology of rodents in grain storage," "Pest birds in grain stores," and "Chemical control of vertebrate pests." A control demonstration on vertebrate pests was presented with the assistance of Messrs. Ejaz Ahmad and Shahid Munir.

Mr. Joe Brooks, Project Leader, VPCP, received an International Honor Award from USDA/OICD during FY-89 in recognition of his work in Pakistan.

Radio broadcasts from Lahore were given on control of wild boar and porcupine. Lectures and training were given to Agricultural Officers from the Faisalabad Plant Protection Institute.

On World Food Day, an exhibition was arranged by NARC from October 16 to 19, 1988. An exhibit of pest animals, crop damage, and methods of control was displayed by VPCP staff. The exhibition was visited by diplomats, Ministers of Islamic countries, scientists, farmers, students, etc.

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PROJECT TITLE: Forest Animal Damage Control Research

PROJECT LEADER: James Evans, (206) 753-9450; FTS: 434-9450

INTRODUCTION:

Forest animal damage control is an integral part of the APHIS Science and Technology ADC Research Program. Many species of wildlife adversely affect conifer regeneration in the Pacific Northwest by damaging seeds, seedlings, and trees. Greatest National impact on reforestation is from mountain beavers in coastal forests and pocket gophers in interior forests. Locally severe problems are also caused by porcupines, deer, elk, hare, rabbits, black bear, and miscellaneous rodents. The current mission of the Olympia Field Station is to help reduce the multi-million dollar forest animal damage loss occurring in western forests. Emphasis in 1989 was to retain strychnine bait registrations for control of forest pocket gophers and mountain beavers.

OBJECTIVES:

1. Collect field efficacy data required to maintain registration of USDA-APHIS strychnine baits for forest pocket gophers (Thomomys spp.).

2. Collect field efficacy data required to maintain 24-C registration of "Boomer-Rid" strychnine bait for control of mountain beavers (Aplodontia rufa).

3. Continue research for discovering new ADC program tools and techniques.

4. Aid ADC program by initiating new research projects on forest animal and non-forest animal damage problems.

5. Work closely with ADC Operations, Extension personnel, and Forest Industry representatives on transfer and exchange of information concerning forest animal damage problems and solutions.

ACCOMPLISHMENTS DURING FY-89:

Results of a September 1988 radio-telemetry range-finding toxicity field trial of strychnine steam-rolled oats with molasses for handbaiting Thomomys pocket gophers were submitted to EPA in January 1989. Protocols for large scale tests to determine efficacy of strychnine (molasses formulation) steam-rolled baits for handbaiting and burrow builder baiting Thomomys under actual-use conditions were submitted to EPA in January 1989 and March 1989, respectively. In cooperation with the U.S. Forest Service (Region 4 - Ogden, UT), operational handbaiting tests were conducted on the Targhee National Forest in eastern Idaho June 11 through August 28, 1989; operational burrow builder studies were conducted on the Targhee July 25 through September 25, 1989. The studies were partially funded by APHIS-S&T, the U.S. Forest Service's National Agricultural Pesticide Impact Assessment Program, and the Targhee National Forest - Ashton (ID) Ranger District. All test results will be submitted to DWRC before January 1990.

A radio-telemetry range-finding field trial in western Washington with "Boomer-Rid"--a pelleted strychnine bait for mountain beaver control--was completed in spring 1989. The study was done in cooperation with the Oregon Rodent Control Outfitters (ORCO) and the Washington State Department of Natural Resources. Results of the study were submitted to EPA in September 1989. A protocol was also submitted to EPA through ORCO for a large scale, actual-use field efficacy study of "Boomer-Rid" in Washington and Oregon in FY-90. The study will be for state or national registration of this underground handbait for mountain beaver control.

Field trials were initiated to compare effectiveness and efficacy of ORCO's strychnine (Rhoplex formulation) oat bait and Eaton's diphacinone anticoagulant bait block for handbaiting forest pocket gophers in the fall and in the spring. The study is being done in cooperation with the U.S. Forest Service (Region - 6, Portland, OR) and is being conducted and partially financed by the Rogue River, Winema, and Fremont National Forests in southern Oregon. Fall study plots were established in July 1989 and were contract baited in September 1989; they are scheduled for activity assessments in fall of 1989. The spring baiting evaluation will run from early 1990 through late 1990.

Pilot studies and probes initiated in FY-89 include the following:
-- Field evaluation of Scram S-42 (thiram, TMTD, tetramethylthiuram disulfide) for reducing damage to Douglas-fir by mountain beavers.
-- Field evaluation of powdered whole starling (Sturnus vulgaris) as an aversive conditioning agent to reduce damage to Douglas-fir seedlings by mountain beavers.
-- Pen and field evaluations of sticky knock-down devices as hair collectors to identify and index small mammal activity in mountain beaver burrow systems.
-- Field probe of indiscrete placement of hand-bait (carrot or steam-rolled oats) for control of forest pocket gophers.
-- Field assessment of plot size (1/100 A vs 1/50 A) for determining pre- and post-baiting activity counts of pocket gopher mounds and open-holes.
-- Field assessment of area coverage of contract handbaiting of pocket gophers in forest clearcuts.

Pilot studies that were continued from previous starts included:
-- Reoccupancy of mountain beaver nests and burrow systems in Douglas-fir clearcuts.
-- Reinvasion by mountain beavers of burned and unburned forest clearcuts where mountain beaver populations had been controlled by baiting and/or trapping.
-- Development of mountain beaver censusing techniques.

Each of these pilot studies and probes warrant further study. Another FY-89 probe indicated that an arctic hare repellent had little potential against mountain beavers and should not be studied at the present time.

Considerable information in the form of progress reports, publications, and consultations was transferred to ADC Operations, the U.S. Forest Service, and other public/private cooperators and institutions.

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PROJECT TITLE: Assessment of Problems, Economics, and Hazards Related to Small Mammal control

PROJECT LEADER: Paul L. Hegdal, (303) 236-7809

INTRODUCTION:

The purpose of this project is to determine if potential hazards to nontarget animals exist with registered and unregistered rodenticides, and to study the biology, behavior, ecology, distribution, and the importance of nonpredatory mammals that cause economic, health, safety, and interspecies problems. In addition, environmental data are required for decision-making regarding the registration and reregistration of toxicants, and for evaluating the social-political aspects of animal damage control. Furthermore, research on biology and life history of problem species (especially Sciurid rodents) is necessary for the development of damage control methods based on sound biological, economic, and environmental considerations.

OBJECTIVES:

1. Determine if potential primary and secondary hazards exist with registered and candidate vertebrate control materials.

2. Provide new data on the biology, behavior, distribution, and the economic importance of small mammal species of concern to the ADC program.

3. Assist other Center projects as needed, especially with radiotelemetry applications and hazard evaluations.

ACCOMPLISHMENTS:

In cooperation with private industry and Bowling Green State University, we are continuing to evaluate the potential long term impact on a common barn owl population of an anticoagulant rodenticide used on farmsteads. This study also has provided new insight into barn owl ecology and management that has been very helpful to the midwestern states.

In collaboration with private industry, 42 evaluations of cable or duct resistance to pocket gophers were conducted during the year.

Cooperative studies with the Bureau of Reclamation (BR) continue. A manual on identifying mammalian species and controlling damage they cause to hydraulic structures is nearing completion. Because of the lack of BR funding, completion of the manual has been delayed, but it will be completed in FY-90.

Project personnel assisted other section projects with major telemetry field studies on Columbian ground squirrels in Montana, northern and plains pocket gophers in Colorado, and plains pocket gophers in Texas. Also, project personnel provided assistance with animal acquisition and

toxicologial tests of other section projects. Results of these studies are reported by other section projects.

The project leader made 4 presentations on animal damage to hydraulic structures at the Bureau of Reclamation Workshop, in February 1989 at Denver; 3 presentations on radiotelemetry in wildlife short courses and classes at Colorado State University in Fort collins; and participated in teaching a Vertebrate Pest Management class at Colorado State University.

REPORTS AND PUBLICATIONS:

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PROJECT TITLE: Small Mammal Control in Rangeland and Agricultural Crops

PROJECT LEADER: George H. Matschke, (303) 236-7819

INTRODUCTION:

Nonpredatory mammals cause losses of food and fiber estimated at $0.5 billion dollars annually in the U.S., exclusive of losses caused by commensal rodents. These losses involve conifers (mice, pocket gophers, mountain beaver, porcupine, deer, elk); apple orchards (voles); rangeland and pastures (prairie dogs, ground squirrels); cereal crops (mice, voles, ground squirrels); and forage crops (pocket gophers, voles). Research at the DWRC has been directed toward development of control methods for several species of rodents (especially prairie dogs and ground squirrels), and limited ecological-behavioral studies of select genera to determine the significance of their impact on western range and agricultural lands, domestic livestock, and other wildlife. The goal of research is to develop efficacious control methods that are safe and economical.

OBJECTIVES:

1. Obtain toxicological data required for the reregistration of zinc phosphide for controlling rodents.

2. Obtain toxicological and efficacy data for the reregistration of strychnine for controlling ground squirrels.

3. Evaluate the toxicity of 1080 concentrations below the 0.125% concentrations previously registered for controlling rodents.

4. Obtain toxicological data for the reregistration of strychnine for controlling small mammals other than ground squirrels.

5. Evaluate the potential of cholecalciferol (Vitamin D_3) and benzenesulfonic acid hydrazide (DRC 4575)as rodenticides for rangeland and agricultural rodents.

ACCOMPLISHMENTS:

Data required by the U.S. Environmental Protection Agency for the reregistration of strychnine were submitted. These data included the efficacy of various strychnine concentrations that were evaluated in laboratory feeding trials with both the northern and plains pocket gophers.

A field study was conducted in Montana to evaluate two 1080 concentrations (0.02% and 0.03%) that are lower than the registered concentration (0.05%) on Columbian ground squirrels. Two pilot field studies were conducted in Texas and in Colorado to measure the efficacy of strychnine for controlling pocket gophers.

Two new potential rodenticides, cholecalciferol (Vitamin D_3) and benzenesulfonic acid hydrazide (DRC 4575) were evaluated in laboratory feeding trials with pocket gophers.

A trip was made to Pakistan to evaluate methods for controlling wild boar damage to agricultural crops and to recommend research approaches.

REPORTS AND PUBLICATIONS:

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PROJECT TITLE: Rat Control in Hawaiian Macadamia Orchards and Sugarcane Fields

PROJECT LEADER: Mark E. Tobin, (808) 961-4482

INTRODUCTION:

Rodents are significant agricultural pests in Hawaii. Between 10% and 20% of the sugarcane crop is lost annually due to depredations by Norway rats (Rattus norvegicus), black rats (R. rattus), and Polynesian rats (R. exulans). This damage costs the state's largest agro-industry between $10 million and $20 million annually, depending on the prevailing price of sugar. Between 3% and 5% of the macadamia nut crop is damaged by black rats. In 1988 the resulting losses for the state's sixth largest agro-industry was between $1.1 million and $1.8 million. To assess the economic impact of rodent damage and control measures, and to evaluate and develop more effective control measures, in November 1988 the Denver Wildlife Research Center reopened its rat research field station in Hilo.

OBJECTIVES:

1. Initiate a research and development program to reduce rodent depredations in Hawaiian sugarcane fields and macadamia orchards.

2. Establish cooperative relationships with state, federal, and private interests to alleviate animal damage problems.

3. Develop a more effective rodenticide for controlling populations of Norway, black, and Polynesian rats.

4. Further our understanding of the biology, ecology, and impact of Norway, black, and Polynesian rats in and around sugarcane fields and macadamia orchards.

ACCOMPLISHMENTS DURING FY-89:

The Hawaii Field Station laboratory and office facilities were refurbished, furnished, and reopened in June, 1988. A secretary (typist) and a biological aid were hired.

Twelve Standard Operating Procedures were written for trapping, handling, and working with rats, mixing and administering toxic chemicals, conduting experiments, and performing other duties associated with the project.

One field and six laboratory Study Protocols were prepared.

An extensive trapping study was conducted to define the relative importance of the three depredating species of rats on sugarcane plantations on the islands of Kauai and Hawaii, and to define the major cultural and environmental variables associated with the distributions and abundances of these pests.

A meeting of Hawaii animal damage control specialists was attended in April.

In May a visit was made to Kauai to meet HSPA and sugarcane plantation personnel and to survey rat depredation problems.

In May a talk on rodenticides and rat control procedures was given in Hilo to Hawaii Vector Control personnel.

In August one-day training classes on rat control were taught to sugarcane plantation personnel on the islands of Kauai and Hawaii.

In September trapping was begun to capture wild animals for laboratory evaluation of rodenticides.

Consultations regarding rodent control were held with Fish and Wildlife Service, National Park Service, sugarcane and macadamia plantation, and Hawaii Vector Control personnel.

Mongoose and rat tissue samples were prepared for diphacinone residue analyses.

PROJECT TITLE: Identification of Mammalian Sensory Characteristics

PROJECT LEADER: Stephen A. Shumake, (303) 236-7869

INTRODUCTION:

Nonpredatory small mammals (e.g., rats, mice, voles, pocket gophers, prairie dogs, ground squirrels) cause extensive damage to agricultural crops, are often the main vectors of disease transmission to domestic livestock and humans, can cause safety problems on rangeland as well as at airports, and often impose a threat to desirable species due to their rapid breeding cycles, food habits, and burrowing activities. Although many types of ADC materials and methods are currently registered and available for controlling damage caused by these problem species, more restrictive Federal regulations, as well as concerns about potential hazards to other wild species, have generated a continuing need to improve the efficacy, safety, and selectivity of control materials and methods. Research activities of this Project are directed toward identifying and defining behavioral parameters and animal vulnerabilities important to the discovery and development of improved small mammal control methods.

OBJECTIVES:

1. Complete data analysis and report writing (Tasks 2 and 3) required for the U.S. Army Ft. Detrick red-phosphorus smoke contract (Project Order No. 85PP5847).

2. Evaluate taste and odor attractants that have the potential to improve efficacy of rodenticide bait formulations for controlling nonpredatory mammals.

3. Evaluate the potential efficacy of new control materials and devices for repelling or eliminating rodents under simulated or field conditions.

ACCOMPLISHMENTS DURING FY-89:

Data collection for the smoke contract relating to startle responses of prairie dogs and rock doves was completed in October 1988. These data were analyzed with the cooperation of the DWRC Research Support Section personnel by May 1989. A draft of the Task 3 report was mailed to the U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, MD in September 1989.

Data analyses of Task 2 Studies (Effective smoke concentration range-finding determinations) were completed early in FY 89 and the review draft was distributed in April; it was revised and the final report was mailed to Ft. Detrick and other users in October 1989.

Published reports from Dr. J. Russell Mason were reviewed and consultations were conducted in regard to carbon disulfide as a potential rodenticide bait attractant. No formal tests of the concept or compound, however, were

conducted by Project personnel during FY 89 due to time and laboratory space limitations. This area of work will be pursued during FY 90.

Two manuscripts concerning vehicle-mounted ultrasonic devices to be used as repellents for deer and elk were reviewed. Field efficacy test data related to commercial ultrasonic rodent repellent devices were reviewed for Mr. Harrison Sheppard (Federal Trade Commission, San Francisco, CA).

The Project Leader assisted other Section personnel in collecting data in the Montana field study to evaluate efficacy of low level concentrations of 1080 grain baits on Columbian ground squirrels.

REPORTS AND PUBLICATIONS:

Shumake, S. A. and R. W. Bullard (Eds.) 1988 Vertebrate Pest Control and Management Materials: 5th Volume. ASTM Sp. Tech. Publ. STP974. 189 pp.

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PROJECT TITLE: Ecology and Behavioral Applications

PROJECT LEADER: Frederick F. Knowlton, (801) 750-2505

INTRODUCTION:

Coyotes are a dominant and controversial animal throughout most of the U.S. Despite several decades of intensive coyote management, neither the dynamics of coyote populations nor their impact upon other populations is understood. This project is designed to apply information associated with population mechanics, behavioral patterns, and interactions with natural and domestic prey populations to develop and improve methods and techniques used in depredation control efforts as well as anticipating the needs for depredation control efforts.

OBJECTIVES:

1. Promote understanding and resolution of animal damage control problems through acquisition and dissemination of the most appropriate information available.

2. Identify coyote behavioral traits and patterns relevant to management of coyote depredations on domestic livestock.

3. Develop an understanding of the interactive influences among coyote populations, abundance of natural prey, and depredations on domestic livestock.

4. Investigate coyote population processes as they relate to attempts to curtail depredations on domestic stock through the use of population reductional techniques.

5. Provide logistical support, assistance, and counsel to other research efforts attempting to develop or improve coyote depredation control techniques and procedures.

ACCOMPLISHMENTS DURING FY-89:

This Project responded to numerous requests for information originating from the ADC Program and other S&T Research groups, as well as from outside agencies and the general public. Most notable was a review of documents associated with a proposal to reintroduce the Mexican Wolf to White Sands Missile Range of New Mexico.

Data collected in cooperation with the Chemical Development/Registration Section supporting chemical registrations included evaluations of 2 formulation marking agents for use with existing ADC tools and toxicity probes of 3 potential predacides. The former included tests of DAY-GLO fluorescent particles (an alternative to Tracerite) as a marking agent for use in M-44s and tartrazine, also known as FD&C Yellow #5 (an alternative to rhodamine B), as a dye for use in the Livestock Protection Collar (LPC). Both marking agents performed satisfactorily in the tests. In the chemical toxicity tests, the oral toxicities of cholecalciferol, amidephrine

mesylate, and sodium diphacinone to coyotes were investigated. The median lethal doses (LD_{50}) of the last two were calculated at 2.0 mg/kg, with 95% confidence intervals of 1.0-4.0 mg/kg. Similar calculations were not possible for cholecalciferol within the dose range examined.

A study is in progress to determine whether aerial hunting efforts on mountain grazing allotments in winter are likely to remove coyotes that would be present in summer when depredations on sheep are common. Field work was completed with the capture, attachment of radio transmitters, release, and monitoring seasonal movements of 17 coyotes. All coyotes between 6 and 22 months of age made at least one significant change in area(s) of use while all coyotes over 22 months of age utilized the same locations during winter as during the summer grazing season.

The accuracy of the aerial telemetry system used to locate radio-equipped coyotes in mountainous areas was assessed. Overall, the estimated locations of transmitters determined by an observer in a fixed-wing aircraft averaged less than 101 yards from the true locations. When the 3 estimates that the observer considered "poor" at the time of the observations are excluded, the estimated locations averaged 76 yards from the true locations.

Development of a suitable tranquilizer trap-tab to be used when capturing depredating wolves was delayed by difficulty in locating a source of the desired drug. The Chemical Development/Registration Section has initiated discussions with the Food and Drug Administration regarding tests and test procedures required for registration of such tranquilizer trap tabs.

A study was designed that will attempt to identify characteristics of coyotes responsible for killing livestock, as well as those that feed on freshly killed livestock. The initial phases of the study were conducted on a ranch in Texas during spring, 1989. Coyote density on the ranch was estimated at 1.25 coyotes/sq. mi. on the basis of scat deposition rates. Among a total of 11 ewes, 11 lambs, 13 angora does, and 13 kids grazed on the study area, 1 ewe, 6 lambs, 2 does, and 7 kids were killed by coyotes. Preparations for field data collection in FY-90 were completed.

Two study protocols related to developing both physical and physiological markers to identify coyotes that kill livestock, ingest livestock flesh, consume baits, or otherwise come in contact with ADC equipment or materials were drafted and approved. A preliminary assessment indicated that the elevated blood-iodine levels in sheep resulting from injections of iophenoxic acid can be transferred to coyotes in a single feeding of 500 g of flesh from treated goats. Subsequently, a study was initiated to determine the amount of iophenoxic acid required in goats to provide recognizable marking of coyotes that feed on treated goats during a 4-month period. Planning was begun for a second study to assess the utility of using radioisotopes in physiologic marking collars to identify coyotes responsible for killing goats.

In cooperation with other Projects within the Section, 3 pilot studies to identify the toxicity of 3 candidate chemicals to coyotes were developed and will be conducted early in FY-90.

A study protocol to identify suitable materials to be used as carriers for chemical formulations in the Coyote Lure Operative Device (CLOD) was drafted and is currently in the review process.

A study on the impact of tubal ligation and vasectomy on pair-bonds and territorial defense behaviors has been initiated using a computerized data recording system. This study will help assess the potential for use of sterilization techniques in predator control.

A parallel study to assess the influence of hormones on the annual pattern of coyote pair-bonding and territorial defense behaviors is in the preliminary stages with a draft protocol now under review. Development of various endocrine assays suitable for use on coyotes is in progress.

REPORTS AND PUBLICATIONS:

Burgess, E. C., and L. A. Windberg. 1989. Borrelia sp. infection in Texas coyotes, jackrabbits, and cottontails. J. Wildl. Diseases 25(1):47-51.

Burns, R. J., G. Connolly, and P. J. Savarie. 1988. Large livestock protection collars effective against coyotes. Proc. Vertebr. Pest Conf. 13:215-219.

Gionfriddo, J. P. and L. C. Stoddart. 1988. Comparative recovery rates of marked coyotes. Wildl. Soc. Bull. 16:310-311.

Knowlton, F. F. 1989. Predator biology and livestock depredation management. Proc. West. Sect. Amer. Soc. Anim. Sci. 40:504-509

Knowlton, F. F. 1988. Questions and answers on coyotes. . . . Interview in The Cattleman, November 1988, 24, 26 and 28 pp.

Mills, L. S., and F. F. Knowlton. 1989. Observer performance in known and blind telemetry accuracy checks. J. Wildl. Manage. 53(2):340-342.

Pence, D. B., F. F. Knowlton, and L. A. Windberg. 1988. Transmission of Aancylostoma caninum and Alaria marcianae in coyotes (Canis latrans). J. Wildl. Diseases 24(3):560-563.

Windberg, L. A., and F. F. Knowlton. 1988. Management implications of coyote spacing patterns in southern Texas. J. Wildl. Manage. 52(4):632-640.

PROJECT TITLE: Field Evaluation

PROJECT LEADER: Roger D. Nass, (208)733-0186

INTRODUCTION:

A variety of materials, methods, and production practices are needed to effectively minimize coyote predation on livestock. This project emphasizes evaluation of modified or new control techniques and methods in field studies. Field tests are conducted to develop more efficient methods of controlling coyote predation on livestock and to provide biologically sound data for management decisions. Assessment of possible exposure of nontarget species to control agents is an integral part of field evaluation.

OBJECTIVES:

1. Improve the utility of baits for delivery of control agents.

2. Assess baiting techniques for delivery of control agents.

3. Devise methods to minimize exposure of baits and other control materials to nontarget species.

4. Assess the utility of laboratory improved coyote lures in field tests of control devices.

5. Assist in cooperative testing of potential improvements in control methods (the livestock protection collar, the M-44, and others).

ACCOMPLISHMENTS DURING FY-89:

Nontoxic tallow baits (NTTs) were used during field studies to evaluate coyote acceptance of small baits. Each NTT weighed about 4.5 g and had the following composition: 90% beef tallow, 10% white beeswax, 10 mg iophenoxic acid (IA) for marking coyotes' blood, and 100 mg metallic flakes for marking scats. Coyotes appear to consume these tallow baits readily if bait sites are encountered. Preliminary tests with another DWRC project showed promising results in the development of another physical marker for coyote scats. IA analysis of coyote blood samples is now routine due to cooperative Project and Section efforts.

A backlog of coyote blood serum was analyzed for fall and winter acceptance tests of tallow baits placed at 5 per square mile. The two fall test plots yielded 42% marked blood samples and 52% marked scats. The winter plots had 50% marked blood and 65% marked scats.

The winter and summer portions of a four-season coyote bait acceptance study were completed. Nontoxic tallow baits, containing physical and physiological agents for marking coyote scats and blood, were placed at densities of 2, 5, and 20 per square mile. Marked scat and blood samples provided two indices for determining the best bait density for optimum acceptance by coyotes. At bait densities of 2, 5, or 20 baits during

summer, percentages of scats marked were 17, 17, and 33, respectively, while winter results were 45, 58, and 100. Preliminary interpretation of summer test blood sample results also indicated lower acceptance during this season by coyotes. Seven, 18, and 27% of the coyote serum samples were marked at bait densities of 2, 5, or 20 per square mile; whereas 60, 15, and 67% were marked at the same bait densities during winter. Nearly one-half of the summer blood samples were collected from juvenile coyotes; only one (6%) of these samples indicated acceptance of tallow baits.

Elevated baits, use of dirt hole sets, and burial have shown potential for reducing bait consumption by nontarget species; however, use of these methods may cause unacceptable reduction in coyote bait consumption. A pilot study was completed comparing disappearance and species acceptance of 100 pairs of rock-covered and cowchip or vegetation-covered NTTs. After 9 days, 28% of the rock-covered NTTs were missing; 12% were apparently taken by coyotes, 12% by rodents. A total of 89% of the baits covered with grass or cow chips were missing. Of these, rodents removed 54%, coyotes, 16%. The results indicated that tallow baits covered with heavier materials discouraged removal by rodents, but did not preclude discovery and consumption by coyotes. A second trial of heavier NTT coverings was completed as a portion of the summer 3-bait density study. After 6 days' exposure on 3 plots, 73% of the NTTs covered with chips or grass and 57% of the NTTs covered with rocks were missing. Chip/grass-covered NTTs disappeared significantly faster than rock-covered NTTs on 1 of the 3 plots. Rock-covered NTTs had less rodent activity near them and were not as susceptible to melting during periods of high temperatures. Covering baits with heavier materials warrants further testing as a means to reduce bait removal by nontarget species and maintain adequate discovery and consumption by coyotes.

Cooperative efforts were successful in developing and testing miniature transmitters for inclusion in tallow baits to examine removal or consumption by nontarget species. A pilot study demonstrated the potential usefulness of this tool for monitoring bait disappearance and to help determine which species were involved. During the winter bait acceptance test, 6 of 18 (33%) baits with transmitters were moved distances of 2 to 80 feet (mean = 29) from placement sites. Eight of 18 (44%) transmitter-equipped baits were moved 2 feet to 100 yards during the summer test (mean = 70 feet). Eight baits were moved less than 10 feet from the placement site. Desert wood rats (Neotoma lepida) accounted for the 2 long-distance bait removals.

During the winter test, snap traps near baits caught 77 deermice (Peromyscus maniculatus) and 9 kangaroo rats (Dipodomys ordi). Metallic flakes were found in 19 of 29 (65%) deermice and 2 of 2 (100%) kangaroo rats trapped near baits containing these markers. In summer, snap traps set near bait sites caught 47 deermice, 8 chipmunks (Eutamias minimus), 8 ground squirrels (Citellus richardsoni), 5 rock wrens (Salpinctes obsoletus), 3 voles (Microtus longicaudus), 2 wood rats, and 2 kangaroo rats. None of these contained metallic flakes.

PROJECT TITLE: Depredations Control

PROJECT LEADER: Samuel B. Linhart, (303) 236-7813

INTRODUCTION:

Livestock predation by coyotes is a historic and chronic problem in mid-western and western U.S. The expansion of coyotes into the eastern states has resulted in additional depredation problems. Management of coyote predation and other wildlife-caused damage requires the development and deployment of safe, selective, and effective control techniques. Livestock producers place high priority on the development of cost-effective techniques; conservation groups and other large segments of the public favor methods that do not affect nontarget wildlife. Project objectives seek to develop management methods that can satisfy the goals of both public factions.

OBJECTIVES:

1. Investigate stimuli/techniques for attracting coyotes to control devices/area.

2. Investigate stimuli/techniques for repelling/excluding coyotes from livestock.

3. Develop improved coyote capture devices and evaluate efficacy and selectivity.

4. Assess methods for controlling rabies in wildlife.

5. Investigate control of eagle predation on livestock.

6. Assess eastern carnivore problems and evaluate damage control methods.

ACCOMPLISHMENTS DURING FY-89:

Evaluation of the seasonal responses of captive coyotes to 9 chemical attractants continued at the Predator Research Facility near Millville, Utah. W-U lure (trimethylammonium decanoate plus sulfides), TMAD lure (trimethylammonium decanoate), SFE (synthetic fermented egg), FAS (fatty acid scent), and VFA (monkey pheromone) were tested during 3 seasons of the year, while smoked fish flavor, artificial liver flavor, yeast autolysate, and decanoic acid were tested only during the summer months. FAS produced the greatest total response time from coyotes during all seasons of the year, followed by W-U lure. FAS, W-U lure, smoked fish, and artificial liver flavor evoked the most lick-chew-bite and pulling behavior during the summer months and have potential for improving the performance of M-44 devices in warm weather.

Portable battery-operated coyote frightening devices were again provided to various ADC state or district offices for operational evaluation. FY-89 was the third and final season for these cooperative field tests. A total of 40 reports from 10 states have now been received. Tests were conducted

in a wide variety of habitats in conjunction with various ADC control efforts and sheep management practices. Data are being analyzed and will be reported to cooperators in FY-90.

Preliminary tests were conducted to determine the amount of tension that deer, calves, and lambs applied to standard cable snares. Fawn mule deer produced tension loads ranging from 140-360 lbs and averaging 257 pounds. Adult deer produced readings ranging from 560-800 pounds and averaging 690 pounds. Twelve calves produced tension loads averaging 1,183 lbs, while lambs averaged 563 lbs. Differences in tension loads between coyotes and nontarget species may allow for the development of snares that will consistently hold coyotes while releasing most larger nontarget animals.

Earlier field tests of padded-jaw coyote traps showed a greatly reduced efficiency for the Woodstream No. 3 Soft Catch trap compared to both unpadded double-coil or long-spring traps. A third field test conducted i south Texas in Jan-Feb 1989, compared the efficiency of the Soft Catch tra with an identical but unpadded trap and the standard ADC 3NM victor. The test this year differed in two respects; first, the levers on the Soft Catch were shortened and, second, a Woodstream representative demonstrated special trap setting procedures for the Soft Catch trap and was present th entire test period. The results obtained under generally optimal trapping conditions, showed comparable trapping efficiency for both padded and unpadded traps. Trap setting procedures were believed responsible for increased efficiency of the Soft Catch traps. Efficiencies under difficul or marginal trapping conditions remain unknown.

Cooperative evaluation of raccoon baits containing ampules for delivering oral rabies vaccine was continued at a U.S. Public Health Service, Centers for Disease Control facility in Lawrenceville, Georgia. Nine of 10 captiv raccoons were successfully vaccinated by consuming test baits containing a recombinant vaccine. A manuscript describing this research is being prepared for publication. Field tests of untreated DWRC bait were conducted in Georgia in collaboration with the Georgia Department of Natural Resources and in Maryland with the Maryland Department of Health and Mental Hygiene. Acceptance of baits by free-roaming raccoons was high with complete consumption of both the bait and the enclosed ampule. Preliminary work was initiated and technical advice was provided on baitin and bait requirements for delivering chemicals or biologics to coyotes, dogs, and mongooses.

Field work continued to examine the feasibility of resolving golden eagle depredation on livestock by relocating specific birds known to be livestoc killers. Six resident golden eagles (3 males and 3 females) were captured near Sheridan, Wyoming. This group consisted of individuals from 6 pairs that were color-marked, equipped with radio transmitters, and released approximately 300 miles northwest of the capture area. All eagles were absent from their territories for at least 42 days following relocation. Ultimately, 3 of 6 eagles returned to their territories.

REPORTS AND PUBLICATIONS:

Connolly, G. E. 1988. M-44 sodium cyanide ejectors in the Animal Damage Control Program, 1976-1986. Proc. Vertebr. Pest Conf. 13:220-225.

Fall, M. W. 1988. Control methods for the future. In: F. Leydet. The coyote. Univ. of Okla. Press, Norman. 224 pp. (reprinted excerpt of 1984 paper)

Linhart, S. B., F. S. Blom, G. J. Dasch, and R. M. Engeman. 1988. Field evaluation of padded jaw coyote traps: effectiveness and foot injury. Proc. Vertebr. Pest Conf. 13:226-229.

Phillips, R. L., and F. S. Blom. 1988. Distribution and magnitude of eagle/livestock conflicts in the western United States. Proc. Vertebr. Pest Conf. 13:241-244.

PROJECT TITLE: Biochemistry Applications

PROJECT LEADER: Huo-Ping Pan, (303) 236-7814

INTRODUCTION:

The fundamental techniques employed in controlling animal depredations have not changed during the period of recorded history. Current materials and methods were generally recognized and used decades, and in some cases, centuries ago. This project emphasizes identification, application, and development of new technologies for improving existing materials and methods and creating new control tools using recent developments in basic sciences.

OBJECTIVES:

1. Develop a testing program for candidate chemical control agents for predators with database support.

2. Identify potentials for chemical modification of existing control agents to improve efficacy and selectivity.

3. Plan and develop a program for investigating biotechnology applications for predation management.

4. Develop materials and analytical methods for marking agents for use in simulating control agents and identifying formulations.

5. Consult and support Center scientists in developing unique biochemical approaches to animal damage control problems.

ACCOMPLISHMENTS DURING FY-89:

Information on 41 candidate chemicals has been collected for the development of a testing program and database for predator control agents.

Three pilot studies were drafted for testing candidate chemicals involving two potential single dose coyote toxicants and one candidate marking agent. Several other fluorescent chemicals were screened for useful properties and rejected for further testing.

A study protocol for the synthesis and the testing of two aminophenones, p-aminobutyrophenone and p-aminovalerophenone, as coyote control agents is being developed. These two compounds may be efficient and selective toxicants for coyotes.

Intensive literature research and review have identified several potential areas for the use of biotechnology techniques in developing new tools for animal damage control, including:

- specific immunological techniques in conjunction with recombinant DNA technology to induce species-specific infertility or sterility.

- introduction of specific genes coding natural animal repellents into non-resistant crops in order to produce crop varieties with built-in repellency.

- the use of species-specific DNA probes in the identification of coyotes or other species preying on livestock.

Exploratory research was initiated to find a simple method to qualitatively identify iophenoxic acid for field analysis of samples.

Seven invention reports have been filed with the Science and Technology Patent Committee: four on predator control, one on rodent control, one on bird control, and one on a novel liquid crystal.

PROJECT TITLE: Statistical Services and Research

PROJECT LEADER: Richard M. Engeman, (303) 236-7835

INTRODUCTION:

The research program of the Denver Wildlife Research Center depends heavily on statistical guidance to maintain quality control, validity, and credibility for its research products. The total involvement approach has been well documented as the optimal method for a statistical group to operate within a larger structure, particularly with the diverse statistical needs of DWRC. DWRC statisticians become involved in projects at the informal planning stage, assist in the development of a study plan and work unit, maintain close contact (including actual involvement at times) while data are gathered, assist in or provide analysis and interpretation of the data, and assure that the reporting documents contain statistically valid inferences. The project performs a vital role in the research programs of the Center.

OBJECTIVES:

1. Provide statistical consultation in all aspects of statistical theory, experimental design, and data analysis.

2. Conduct statistical and collaborative research related to the current and future research program of ADC.

3. Provide statistical review and assistance with manuscripts and study protocols.

4. Assist in data analyses and interpretation.

5. Develop statistical software and computing capabilities.

ACCOMPLISHMENTS DURING FY-89:

Approximately 950 statistical consultations were provided this year. Additionally, 130 formal Requests for Services were completed this year. Field site consultations included a visit near Chestertown, MD, on testing baits and lures for delivering an oral rabies vaccine to racoons; two visits were made to the Targhee National Forest, ID, field site to consult with Olympia field station personnel on study designs for reregistration of strychnine hand-bait and burrow builder baits for control of pocket gophers and to consult with a representative from EPA. One field visit was also made to the Logan, UT, field station on coyote research.

Work on plotless density estimators (PDE's) continued in an effort to enhance a nonparametric PDE and a technical report was prepared. Target applications include animal damage assessment. Nonparametric methods for comparing exponential growth and velocity curves were further developed. A major paper on this was published. Cumulative crop damage through a growing season follows this form and is a target ADC application and is currently being investigated. Collaborative research with the Olympia, WA,

field station was continued. Topics included aversive conditioning for deer and mountain beaver; toxicants and activity indices for mountain beaver; pocket gopher toxicants; deterrents and activity sampling and control of porcupine damage; registration and reregistration of chemicals. Collaborative research was concluded on roof rat damage indices with the Gainesville, FL, field station resulting in the publication of one paper. Collaborative research on data from the Haiti field station continues.

Additional collaborations included studies on coyote condition as well as the potential for secondary toxicity from zinc phosphide killed prairie dogs. Papers from each are submitted for publication. Collaborations were also done on the longevity of bird carcasses in marshes. Inferences are to assessing efficacy of aerial sprayed avicides to target and nontarget species. A paper is submitted for publication.

Techniques for comparing binomial proportions in the small sample size situation were investigated. These are typical data results from toxicity studies. One paper was published, another is in press and four others are submitted or in preparation.

Estimation of density from line transect data when the animals move in response to the observer was investigated via computer simulations and the results are in press. Work on improving techniques for estimating effective levels of chemical repellents was completed and is in press. Seminars on research results were presented at research institutes in the U.S. and Canada. Experimental design and data analyses were taught in the Second International Short Course on Vertebrate Pest Problems and Solutions.

REPORTS AND PUBLICATIONS:

J.F. Bromaghin and R.M. Engeman. 1988. Head-to-head comparison of SAS and ASTM - proposed probit computer programs. Invited paper to Aquatic Toxicology and Environmental Fate: Eleventh Volume, ASTM STP 1007, G.W. Suter II and M.A. Lewis, Eds., American Society for Testing and Materials. Philadelphia. 1988:303-307.

S.B. Linhart, G.J. Dasch, R.S. Blom, R.M. Engeman and G.H. Olsen. 1988. Field evaluation of padded jaw coyote traps: effectiveness and foot injury. Thirteenth Vertebrate Pest Conference 13:226-229.

G.H. Matschke, W.R. Bonell and R.M. Engeman. 1988. Efficacy of trimethecarb as a small mammal repellent when used in no-till corn plantings. Thirteenth Vertebrate Pest Conference 13:82-85.

L.W. Lefebvre, R.M. Engeman, D.G. Decker and N.R. Holler. 1989. Relationship of roof rat population indices with damage to sugarcane. Wildlife Society Bulletin, 17:41-45.

G.D. Swanson and R.M. Engeman. 1988. The one death problem. In abstracts 1988 Epidemiological Research Exchange, Denver, CO, Oct. 2-7, 1988.

PROJECT TITLE: Bioelectronics

PROJECT LEADER: A. Lawrence Kolz, (303) 236-4413

INTRODUCTION:

The Bioelectronics Project regularly assists in the measurement of biological data by providing instrumentation, technical expertise, on-site field support, and applied research. Specialized wildlife telemetry design, development, and production has been sustained as a major work effort of the Bioelectronics Project for many years. Unique radio tracking transmitters continue to be produced for the Denver Wildlife Research Center and other government agencies.

OBJECTIVES:

1. Provide research and development activities in bioelectronics for both the Science and Technology and Animal Damage Control Programs.

2. Provide electronic support and service for Science and Technology with emphasis on Animal Damage Control research.

3. Develop bioelectronics outreach activities with other agencies.

ACCOMPLISHMENTS DURING FY-89:

Electronics personnel supported the Center's radio tracking studies by constructing 372 wildlife transmitters, performing equipment maintenance and repair, providing on-site assistance, and assuring the quality control of that electronic equipment acquired from commercial sources. The use of wildlife telemetry equipment continues to be the most timely, cost effective, and efficient method for evaluating rodenticides and avicides. Transmitters produced per DWRC specifications have proven to be highly reliable, and this durability allows most of the transmitters to be recovered when studies terminate. This recovery reduces the effective cost of the equipment; the same transmitters can be refurbished and used for several studies.

The electronics project cooperated with the National Fisheries Academy, the University of Alaska, and the Bureau of Reclamation under cooperative agreements during FY-89. This work involved research and training programs for the control and capture of fish with electroshocking equipment. Two manuscripts were published by the U.S. Fish and Wildlife Service (Technical Report 22). Workshops were presented in the states of New Mexico, Minnesota, and North Carolina.

Electronics personnel developed instrumentation to measure the restraining forces necessary to contain various size and species of animals caught in leg-hold snares. Field recordings were subsequently obtained for coyotes, antelope, mule deer, domestic calves, and domestic sheep.

The interagency agreement with the Joint Special Operations was extended during FY-89. Under this agreement, the electronics laboratory provided

training, new equipment, consultation, and repair services for the sponsor.

The Section of Bird Damage Control requested electronics assistance for developing telemetry techniques to continuously monitor the movement of ravens during a 6-week period at Camp Pendleton, California. This support involved the acquisition and testing of a data logging radio receiver, the development of the radio transmitter for ravens, the installation of an antenna array, the programming and timing for the data handling, and on-site technician support.

A pilot study was initiated to develop electroshocking techniques to reduce rodent damage in the rice fields of southeast Asia. Several barrier designs were tested, and the electroshock threshhold of the animals determined. This work will be continued next year.

At the request of the Section of Bird Damage Control, an electronics technician prepared about 40 computer graphics for inclusion in a final report to another government agency. This involvement required the training of personnel to operate the graphics program.

REPORTS AND PUBLICATIONS:

Kolz, A. L. 1989. A power transfer theory for electrofishing. Pages 1-11 in Electrofishing, a power related phenomenon. U.S. Fish Wildl. Serv., Fish Wildl. Tech. Rep. 22. 24 pp.

Kolz, A. L. and J. B. Renolds. 1989. Determination of power threshold response curves. Pages 15-24 in Electrofishing a power related phenomenon. U.S. Fish Wildl. Serv., Fish Wildl. Tech. Rep. 22. 24 pp.

PROJECT TITLE: Computer Services

PROJECT LEADER: Paige Groninger (303) 236-7836

INTRODUCTION:

Computer services and capabilities are absolute necessities in a competent research program. There is no feasible alternative to the computer for handling large masses of data or other information and for extracting appropriate research results from them. Computing is used in all phases of the DWRC research program, from initial literature searching and study design, through data acquisition and analysis, to the final publication stage, and in information tracing, retrieval, and dissemination. This project performs an essential role in providing the computer services needed for the research and related functions of the Center.

OBJECTIVES:

1. Build statistical databases and perform statistical computing.

2. Plan, construct, and maintain special databases.

3. Write and/or modify computer programs.

4. Provide ADP training and consultation.

5. Test and maintain computer equipment and software.

6. Test and maintain graphics equipment and software.

ACCOMPLISHMENTS DURING FY-89:

Provided assistance in all aspects of computer use including the ordering of all software and hardware.

New database systems were created in SAS for DWRC users:

- Coyote tracking system for Predator Section at Logan, UT
- Personnel system for Administrative/Program Support Unit
- Weather tracking system for Animal Care Section
- Calendaring system for Chemical Development/Registration Section

Old database systems were updated to reflect new software and technology:

- Predator literature system for Predator Section.
- Computer equipment tracking system for Research Support Section
- Urban literature system for Library
- International Programs mailing list system for International Programs Section
- Request for Services tracking system for Research Support Section

New procedures and programs on microcomputers to help users were developed and documentation in the use of new microcomputer software packages was

written. Center personnel were trained in the use of microcomputer equipment through personal instruction and classes were conducted in PC-PRIMER, MS-DOS, Telecommunications, LOTUS 1-2-3, Word Perfect, and SAS for DWRC staff. Formal consultation visits were made to the following field stations to set up equipment and train personnel: Fargo, ND; Logan, UT; and Starkville, MS. New equipment was installed and tested, including AT&T 6386's, printers (high-speed and PaintJet) and tape-streaming backup units. The Prime minicomputers were maintained and the project assisted with T&A system and XCOP on the Prime. New microcomputer software packages were installed and learned. A Statistical Analysis System (SAS) site license was obtained and SAS was installed on several microcomputers for Center personnel. The computer programmer served on Integrated Systems Acquisitions Project, Requirements and Specifications committees.

PROJECT TITLE: Library and Information Services

PROJECT LEADER: Diana L. Dwyer, (303) 236-7874

INTRODUCTION:

This unit is comprised of the DWRC Library and Information Services, Center Archives, Publications. The DWRC Library provides specialized, immediate information to scientists and operational personnel of the ADC Program. The current library holdings include approximately 17,000 volumes, 4,150 reports, and 260 serial subscriptions. The library is part of the OCLC system for online cataloging and interlibrary loan services, and subscribes to DIALOG, BRS, STN, CIS, VU-TEXT, MEDLARS, LEXIS, and NPIRS database systems for online literature searching. The library provides services for approximately 80 scientists and 450 operational employees of the ADC Program. This Center Archives organizes and maintains all the material related to pesticide registration and Good Laboratory Practices Act requirements. The Publications unit organizes and distributes the publications of DWRC authors.

OBJECTIVES:

1. Provide information services support to ADC research and development activities.

2. Provide information services to ADC Operations, NTSS, the Deputy Administrator's Office, and other ADC cooperators.

ACCOMPLISHMENTS DURING FY-89:

415 computerized database searches were completed for various research and operations projects; 1,659 interlibrary loans were filled; 274 book orders processed; 2,960 reprint requests were filled.

The Library staff assumed responsibility for giving tours of the Center to visitors. Hallway displays on various research projects and accomplishments were designed and put up by library staff.

An optical storage system was ordered to begin a pilot project in the Center Archives.

Two more Compact Disc-Read Only Memory products were added to the library's collection: Pest-Bank from the National Pesticide Information Retrieval System and Chem-Bank, a hazardous substances database.

Librarians Diana Dwyer and Laurie Paulik gave several presentations during the 2nd International Vertebrate Short Course held at Colorado State University August 14-23, 1989.