AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
BATCH #14

1. SUBJECT CLASSIFICATION

A. PRIMARY
Serials

Y-AH10-0000-0000

B. SECONDARY
Agriculture--Pests of plants

2. TITLE AND SUBTITLE
Vertebrate damage control research,annual progress report,calendar year 1969

3. AUTHOR(S)
(101) Denver Wildlife Research Ctr.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1970	46p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Interior

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(Research summary)

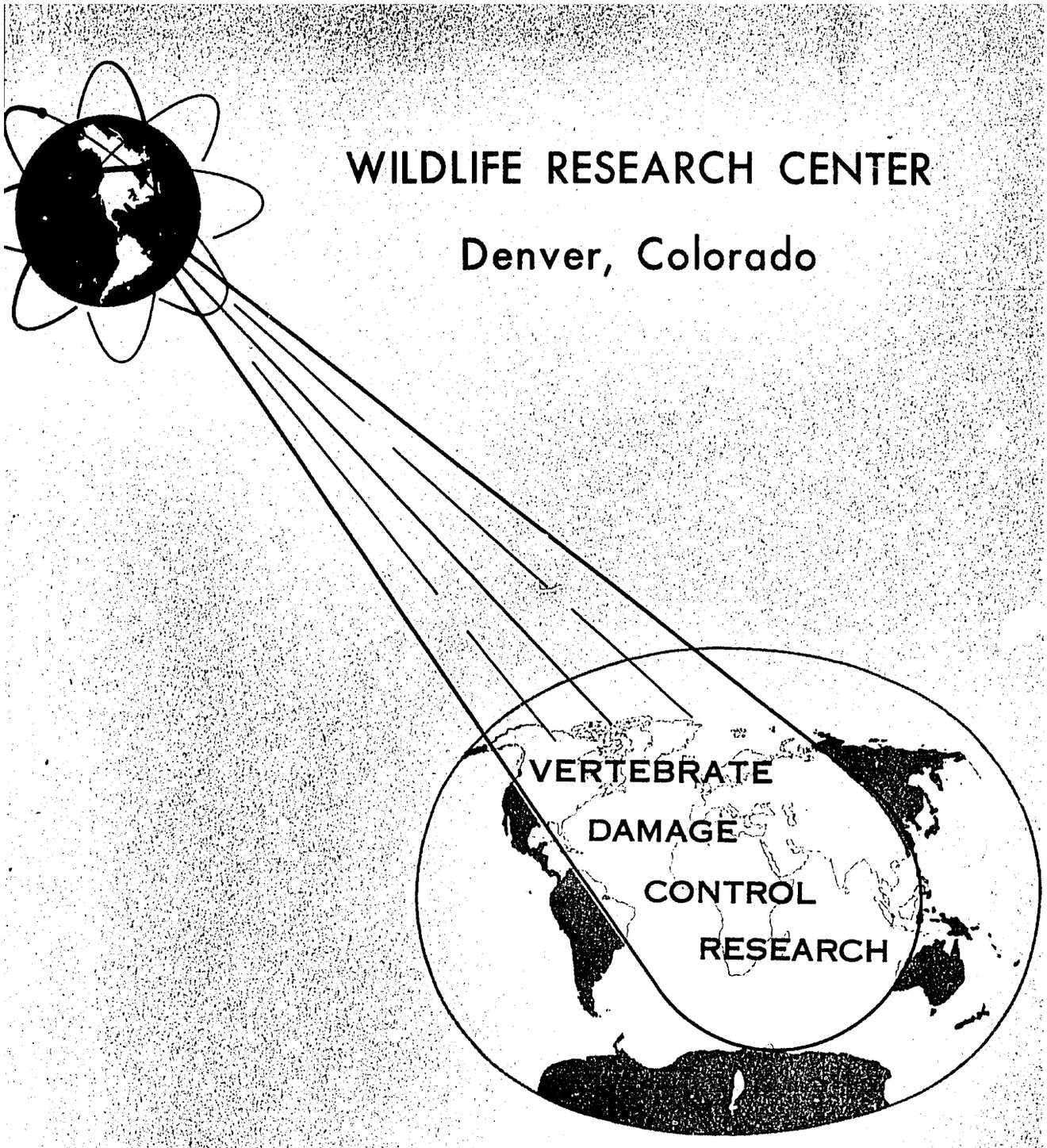
9. ABSTRACT

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-RAA-703	
12. DESCRIPTORS	**13. PROJECT NUMBER**
Pest control	
	14. CONTRACT NUMBER
	PASA RA(ID)1-67 Res.
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

WILDLIFE RESEARCH CENTER

Denver, Colorado



1969 ANNUAL REPORT

A Cooperative Program
of

U. S. DEPARTMENT OF THE INTERIOR
Bureau of Sport Fisheries and Wildlife
Division of Wildlife Research

U. S. AGENCY FOR INTERNATIONAL DEVELOPMENT
Bureau of Technical Assistance
Office of Agriculture and Fisheries

ANNUAL PROGRESS REPORT
Calendar Year 1969

Results Incomplete and Not for
Publication, Release, or Use without
Authority of the Director, Denver Wildlife
Research Center

U. S. Department of the Interior
Bureau of Sport Fisheries and Wildlife
Division of Wildlife Research

U. S. Agency for
International Development
Bureau of Technical Assistance
Office of Agriculture and Fisheries

CONTENTS

Page

Abstracts 1

Basic Research in Mammal and Bird Damage Control

Chemicals 1
Physiology and Behavior 1
Reproduction. 3
Electronics 3

Bird Damage Control Research

Latin America 4

Reports 5

Basic Research in Mammal and Bird Damage Control

Chemicals 5

I. Chemical Screening Activities 5
II. Biological Activity and Chemical Structure Correlation. 7
III. Information Storage and Retrieval Developments. 9

Physiology and Behavior

I. Digestibility and Metabolizable Energy of Blood of Vampire Bats. 10
II. Variation in Concentration of Chemicals on Surface-Coated and in Pelleted Baits. 12
III. Assessment of the Reinforcing Effects of Food Odor in Rats with Operant Conditioning Techniques. 13
IV. Responses of Rats to Potential Attractant Odors in an Open Field Test--Uniformity Trials. 15
V. Taste Preference Instrumentation and Methodology. I. Uniformity Trial. 15
VI. Experiments in Taste Preference Methodology with Rodents. I. Preference for Positive and Negative Stimuli in Different Solid Food Formulation 16
VII. Physiological and Behavioral Response of Red-wing Blackbirds to DRC-736. I. Role of Stomach Fill and Formulation or Variation in Response. 17

Page

Reproduction

I. Rodent Reproduction Studies and Evaluation of Candidate Chemosterilants 18

Electronics

I. Miniaturization and Construction of Transmitters for Small Animals 21
II. Comparison of 30 MHz vs. 164 MHz Frequencies for Radio-tracking Studies. 25
III. Receiving Antenna Systems for 30 and 164 MHz Frequencies 27
IV. Laboratory Screening to Find Sounds Frightening to Starlings 27

Bird Damage Control Research

Latin America

I. Bird Damage Survey. 28

Grain Sorghum 29
Corn. 32
Rice. 33
Other Crops 35
Summary 35

II. Study of Specific Problems. 35

Parakeet Damage to Grain Sorghum. 35
Dove Damage to Soybeans 37

III. Cage Tests of Damage Control Agents 38

Laboratory Data 38
Field Data. 40

IV. Crop Residue Determinations for Damage Control Agents . 41

ABSTRACTS

BASIC RESEARCH IN MAMMAL AND BIRD DAMAGE CONTROL

CHEMICALS

Seven hundred and thirty-two chemical compounds were evaluated for biological activity as candidate animal damage control agents. Fifteen potential repellents and fifteen toxicants passed the screening program as active compounds; these were referred to the Section of Mammals for their review and selection in the development programs.

Additional laboratory equipment, bioassay media, and candidate control compounds were acquired this year through the continued support of the AID program which is concerned with prevention of animal damage, especially that caused by rats and bats in the domestic and foreign problem areas.

Preliminary action was initiated to phase out the empirical screening program which involved suppliers submitting unidentified compounds for bioassay appraisals.

A new program is being developed to evaluate carefully selected candidate control agents based on present day requirements for registration, structure-activity correlations, and thorough review of existing and new literature.

Pharmacological studies related to mode of action will be undertaken to develop new leads in more selective means of control.

The Repellency Index based on functional groups was completed for publication and will be released in 1970.

PHYSIOLOGY AND BEHAVIOR

Physiological, behavioral, and analytical chemistry experiments were conducted pertaining to development of techniques and methodology for controlling damage caused by rodents, vampire bats, and birds. The subject areas are listed along with a brief statement of accomplishment.

1. Digestion and Metabolism of Blood by Vampire Bats. Sixteen bats were used in the experiment. Body weight averaged 32 g and they consumed daily an average of 13.4 mls of blood containing 78% water, 20% protein, 0.2% fat, and 0.2% carbohydrate. Apparent digestion coefficients for protein, fat, and carbohydrate averaged 92.9%, 9.8%, and 2.6%, respectively. Each bat consumed an average of 16.0 kcal of metabolizable energy daily. On an overall basis, the results revealed that vampire bats are highly dependent on the protein fraction of blood as a source of energy.

2. Variation of Chemical Concentration in Surface-Coated and Tableted Grain Baits. The quantity of active ingredients in six grain baits was measured by formulating the baits with carbon^{14}-labeled Mesurol (4-[methylthio]-3,5-xylyl N-methylcarbamate) and determining recovery by liquid scintillation. The materials tested were cracked corn, wheat kernels, and oat groats, each formulated as surface-coated baits and as tablets (ground grain mixed with the chemical and tableted). The surface-coated baits were highly variable, with coefficients of variation ranging from 20.6% (wheat) to 47.2% (cracked corn); Mesurol in individual cracked corn baits ranged from 99 to 532 µg. This much variation could easily explain erratic results in field baiting programs. The tableted baits were much more uniform (coefficients of variation, 4.5% to 7.9%; greatest range, 274 to 360 µg) and are recommended in baiting situations where chemical concentration is critical.

3. Response of Rodents to Food Odors. The reinforcing effects of food odor were measured with an operant conditioning technique. An excessive amount of variability both between and within animals indicated that this procedure was inadequate for screening and scaling potential attractant odors. Albino rats responded twice as fast for food odor and showed less habituation than did hooded rats.

   As an alternative to these operant conditioning procedures, an open-field maze is now being tested with uniformity trials on albino rats. No data are available to report at this time.

4. Taste Preference. Two taste preference experiments were conducted with instrumentation based on the principle of the two-choice foods-together technique. One experiment involved measurement of rats for different concentrations of sucrose. The results are presented in a paper entitled "Electronic Preference Testing Apparatus for Rating Palatability of Solid Foods." The paper has been submitted to a technical journal for publishing in 1970. The other experiment involved measuring consumption preference of rodents for two negative taste stimuli on seven different sizes of food particles. The results indicated that rats show less aversion to such stimuli on the larger food particles.

5. Response of Wild Birds to an Immobilizing Chemical. An experiment was conducted to measure cardiac, respiratory, and key pecking response of red-winged blackbirds to DRC-736 when administered on cracked and pelleted corn on an empty and full stomach. The results revealed that the chemical was markedly more effective in pellets and/or an empty stomach.

REPRODUCTION

The majority of the work reported on for the year is now either published (I-B; I-C), submitted for publication (II-B2; II-C), or manuscripts are in preparation (I-A; I-D; I-E; I-F; II-A; and II-B2). A study of the postpartum estrus of polynesian rats (II-D) revealed that these rats definitely experience a postpartum estrus within 48 hours of parturition. Further, if three or more young are nursing during this period, the development of the fertilized ova is delayed until lactation ceases. The mean gestation period is 22.2 days and litter size averages 3.2 pups.

Two new studies were initiated during the year; determination of the time of formation of the definitive ova (I-G), and a test of the concept of a permanent male chemosterilant (II-E).

ELECTRONICS

Marked improvement in miniaturization and performance efficiency for 30 MHz (megahertz) transmitters for pest species of birds, vampire bats, and small mammals was accomplished this year. Improved components and construction techniques have doubled the signal output, increased life about 50%, and decreased weight of bird and bat transmitters about 20%. These now weigh 4.5 to 5 g, including a 160-mah (milliampere hour) battery and attachment method, and five have run from 18 to 29 days. The miniature collar transmitter has been correspondingly improved and tests indicate that its life has been extended to three to six times that of its larger predecessor. About 190 rat and gopher transmitters have been built by a contractor and checked through this laboratory for field stations. A manuscript will shortly describe miniaturization and construction techniques of the collar transmitter.

Unprotected solar cell clips have continued to power a 1.4-volt transmitter uninterruptedly on the laboratory roof during daylight hours since June 1967.

Limited comparisons of 30 vs. 164 MHz frequencies indicate that neither will be wholly satisfactory for use in all types of wildlife radio-tracking, and that tests in each of the several tracking environments should be run to determine the best frequency for each.

The construction of two double-walled acoustical chambers for screening sounds that might be repellent to birds was completed. After initial chamber-proving tests with starlings, the planned sound screening program was not begun because the principal investigator transferred out of the unit.

BIRD DAMAGE CONTROL RESEARCH

LATIN AMERICA

In 1969, field surveys in six Latin American countries were made to obtain information on bird damage problems in agriculture. Species of icterids, fringillids, psittids, columbids, and anatids caused most of the damage. Grain sorghum, corn, and rice were damaged most heavily. Other crops such as soybeans, wheat, cacao, and mangoes were also damaged, but seldom seriously. Bird damage problems in Latin America were found to be similar to those in the United States, involving many of the same types of crops and genera of birds. It was concluded that research conducted in one area should be beneficial for the other.

Two specific problems were investigated in field studies--parakeets in grain sorghum and doves in soybeans. Parakeets were easily netted and were found to be very responsive to broadcast distress cries; however, at the present time a large labor patrol for a short period of time appears to be the cheapest and most effective method of protecting sorghum from parakeets. DRC-736 applied to soybean seeds before planting greatly reduced damage by eared doves to germinating seeds.

Toxicants, soporifics, and fright-producing agents were evaluated with caged birds in the laboratory and the field. Several agents that have proved utility in the U.S. for specific problems, notably DRC-1327, indicated similar efficacy for Latin American species. Other agents were less effective. The need for obtaining cage data before field testing is clear. Development of crop residue information for DRC-1327 progressed with the finding of suitable microanalytical methods for residue detection and the discovery that this promising damage control chemical is not translocated into ears of corn.

BASIC RESEARCH IN MAMMAL AND BIRD DAMAGE CONTROL

CHEMICALS - W. A. Bowles, G. J. Dasch, R. W. Dutton, and S. E. Gaddis

I. Chemical Screening Activities

A. Introduction

The major problems, responsibilities, and work load of this Unit are concerned with screening contracted, solicited, and purchased chemicals to determine their efficacy as toxicants or repellents to control animal damage. Candidate compounds are evaluated with bioassay procedures which include coating them onto wheat seed and measuring acceptance as food when offered to mice; determining their approximate lethal dose levels by gavaging mice, rabbit, and quail; and observing their phytotoxic effects by spraying solutions onto Douglas-fir and bean seedlings.

Data on active candidate compounds are supplied to research units responsible for establishing specificity of biological action with advanced studies as described in the Annual Progress Reports for Work Unit F-16.1, 1963-67. Computorized printouts of test results for each supplier's compounds are distributed to them quarterly, or as data are made available by field stations following completion of their pen or field studies. All data pertaining to results obtained in the screening program are on file at the Denver Wildlife Research Center.

The continuing service status of the Unit was retained this year with no changes in the routine laboratory procedures outlined in the 1965 Annual Report and revised in the 1966 Annual Report. One staff member was transferred at mid-year to a Unit concerned directly with AID-supported programs.

B. Results and Discussion

The Unit processed 732 new compounds this year as compared to 413 procured in 1968. There were 19 manufacturers that contributed 469 newly synthesized or novel chemicals, while 263 compounds were purchased through an AID allotment. Of the 808 initial bioassays completed, 131 compounds exhibited sufficient activity to require establishing the Approximate Lethal Dose levels. There were 32 of these compounds considered as toxic to the test biomedia which were compared to commercially available rodenticides by a concentration-effect test procedure. Of these, 15 were found to be more active than the standards and were evaluated against Coturnix quail for specificity of action. All of these totals represent increases over 1968 in both numbers of compounds evaluated and bioassays completed.

A portion of the AID allotment was used to purchase unique chemicals that are analogs or homologs of known biologically active chemicals containing reactive nuclei, or having peculiar spatial configurations, or are molecules with simple or complex combinations of functional groups. These compounds procured in this manner are those not normally offered by contractural or solicited sources, and they are needed to advance knowledge at the DWRC concerning effective toxicants whose identities are known. The remaining allotment was used to purchase basic equipment and supplies including bioassay media necessary to support and maintain this service activity.

The search for repellents was de-emphasized again this year in favor of finding acceptable toxicants useful in both domestic and foreign problem areas. Thus, only 15 rabbit Approximate Lethal Dose determinations were made this year, and the results were referred to those investigational groups concerned with advanced repellent study programs.

C. Conclusions

For the past several years the duties of this Unit required neither depth of research methodology nor solutions to product development; its bioassay procedures developed data useful to problem oriented projects rather than augmenting disciplines of Basic Research. In view of present day restrictions and requirements for registering novel compounds useful as control agents and the need to establish their precise role in altering animal behavior patterns, new concepts and guidelines for screening activities have been proposed to update the functions of this Unit in serving the Section.

The following details, in sequential order, the three-step program indicated for achieving this transition:

1. Inform all new suppliers and current contributors to our screening program that we will accept only identified compounds for appraisal Request all contractual sources that they reconsider and disclose, for as many as they can, the identities on the more than 3,000 compounds we have evaluated for them on which we have neither the chemical name nor structural formula. This action is fundamental to advancing our knowledge in the study of correlating chemical structure to both animal repellency and toxicity.

2. Expand our existing data repository by adding the information obtained through a literature search for the bioassay results released by other sources such as industrial, institutional, and governmental agencies that conduct testing programs. New leads in

selecting unique compounds or novel molecular components are realized from such a survey, in addition to eliminating testing compounds previously evaluated.

3. Determine the role of a chemical in inducing a toxic or repellent physiological effect and relate its mode of action to the end result as measured by new bioassay approaches. These techniques will require the services of one familiar with the design and application of sophisiticated testing equipment. A pharmacologist trained in drug mechanisms and pharmacodynamics is due to report in mid-1970 and the combination of his background plus the knowledge of the present Section staff will advance the basic information in this area.

D. Literature Reviewed

Verno, N. B., and G. A. Hood. 1963. Evaluation procedures and standards--chemical screenings and development for forest wildlife damage. BSFW, 59p.

Verno, N. B., G. A. Hood, and W. E. Dodge. 1965. Development of chemicals to control forest wildlife damage. Proc., Soc. of Amer. Forest. Detroit, Michigan, 222-226.

II. Biological Activity and Chemical Structure Correlation

A. Introduction

The problems of designing compounds eliciting predictable, controllable, and desirable effects on target biomedia have long challenged investigators. Screening programs usually embrace the classic approach to isolating effective compounds by empirically evaluating large numbers of chemicals with standardized bioassay procedures. These programs have generated large volumes of data and developed useful supportive measures in controlling animal damage, but there have been relatively few acceptable chemical control agents discovered from these efforts.

A professional function in this Unit's work load structure is concerned with correlating biological activity to chemical structure as one method in an objective approach to "tailor-making" compounds for specificity of action. Any correlative proof or activity rational established through such an approach will intensify cooperation between industrial, academic, and government agencies mutually engaged in the objectives of modifying molecules to potentiate protective abilities.

Fundamental knowledge now exists on the activity of several thousand compounds appraised for repellency properties by the Denver and Patuxent Wildlife Research Centers. A publication listing those compounds evaluated as repellents by the Patuxent food acceptance test method has been authorized by the U. S. Army Natick Laboratories. They have also expressed a willingness to support a publication describing this Center's method to measure repellency by a concentration-effect test method and the results for 1500 compounds assayed by this procedure. Also available for supportive evidence are the results for a small number of identified compounds that were evaluated as both toxicants and repellents. Data from all sources will be reviewed with particular emphasis placed on gross structural considerations and stressing the presence and location of functional groups within an active molecule.

B. Results and Discussion

The Patuxent bioassay procedure evaluated repellency by a food acceptance method and derived a K value indicating rejection or acceptance of food by test rodent. That portion of the publication listing these values for chemicals identified by name in a table arranged according to types and numbers of functional groups has been completed and sent to the coauthor for his review before preparing the text.

The table listing the results of the Denver Center's barrier-effect test against rodents has also been prepared for inclusion in this publication to be printed by the U. S. Army Natick Laboraories. The chemical compounds used in this test were those with K values of 85 or greater at 2%, 1%, and 0.5% concentrations as determined by the Patuxent test. The sponsor from Natick Laboratories thought it worthy for inclusion in the publication.

A table displaying a statistical evaluation of data by presenting the number of compounds tested by Patuxent, their average K values, the K value coefficient of variation, the number of compounds having K values greater than 85, and a derived index that adjusts for variable sample sizes and their weighted K values was completed and included in the publication. This index is a value useful in establishing the role of the individual functional group as it influences repellency; it can be used in selecting those groups that are most likely to impart a high order of activity to molecules containing them either in simple or multiple combinations.

One member of this Unit spent the major portion of this year in preparing this compilation for publication which is scheduled for release in 1970.

A list of compounds screened by the concentration-effect method for rodent repellency as developed by the Denver Center is in preparation. The compounds are listed sequentially by DRC number, chemical name, and test results. This information will be published following completion of the correlation study publication.

C. Conclusions

The proposed reevaluation and redefinition of the Unit's objectives and functions are indicated at this time; the completion of the publication now permits distributing the work load of personnel to those activities concerned with all program modification phases. The study concerning biological activity and chemical structure correlation can be advanced with authorization for additional time and effort in those activities developing refined testing techniques and utilizing recently developed sensory measuring devices.

D. Literature Reviewed

Bellack E., J. B. DeWitt, and R. Trerchler. 1953. Relationship between chemical structure and rat repellency. Chemical-Biological Coordination Center Review No. 5:48-156.

III. Information Storage and Retrieval Developments

A. Introduction

The storage and retrieval of technical information on more than 2,500,000 organic and 50,000 inorganic compounds, in addition to new compounds synthesized each year, is one of the major problems of research groups concerned with chemical-biological relationships. Before this project was activated in 1961, no information storage and retrieval system had been devoted exclusively to recording chemical and physical characteristics and test data for compounds to control animal damage.

The primary objective of this service is adapting and maintaining an information storage and retrieval system on compounds studied at the Denver Wildlife Research Center for use by research units responsible for investigating and developing control agents. Any modification of recording techniques, utilization of new storage media, or application of more effective alerting services are concurrent responsibilities.

The system that was developed and the standardized procedures for encoding data are detalied in the 1961-64 Annual Progess Reports.

The 1966 reorganization evaluated this project's role in serving the Center's needs and concluded that it should be abolished as a separate function; it is now assigned as a collateral duty in the present screening activity. The system serves as a master data file source for compounds studied in the units of the Section of Basic Studies.

B. Results and Discussion

There were no modifications made in the system this year, nor was any time allotted to converting the present notation system to the Wiswesser chemical codification scheme. This activity, also, was curtailed in favor of completing the correlation publication.

We continued to participate in the Center's Chemical Data Dissemination program by supplying the screening results on those compounds procured for initial bioassay procedures during the year, and the updated information received from field stations on those compounds with a pen or field status.

C. Conclusions

Work in this phase of the Chemical Evaluation Unit's responsibilities will be resumed by mid-1970 and consultations are planned with installations using the Wiswesser system.

PHYSIOLOGY AND BEHAVIOR - R. D. Thompson, S. A. Shumake, C. P. Breidenstein, R. W. Bullard, and C. V. Grant

I. Digestibility and Metabolizable Energy of Blood of Vampire Bats

A. Introduction

As far as is known, the vampire bat depends solely on blood of living hosts as a source of food. Such a specialized dietary requirement suggests the need to study the digestibility and metabolizable energy of blood by the vampire. It is believed that the information gained will be useful in developing an effective vampire bat control program.

B. Results and Discussion

The results of the study are summarized in the following table. A brief discussion in also included.

TABLE 1. Blood consumption and the digestibility of blood constituents

	Blood consumed ml	Digestibility			
		Dry matter %	Protein %	Fat %	Carbohydrate %
Male	12.5	90.9	92.9	11.8	-5.6
Female	14.3	90.7	92.9	8.1	9.7
Average	13.4	90.8	92.9	9.8	2.6

TABLE 2. Body weight and metabolizable energy

	Body weight gms	Energy			
		Kcal/gm body wt.	Net req. kcal/day	Met. cons. kcal/day	% efficiency req./cons.
Male	29.3	0.52	5.01	15.11	33.1
Female	35.1	0.48	5.60	16.79	33.4
Average	32.2	0.50	5.31	15.95	33.3

TABLE 3. Composition of blood fed to vampire bats

Blood		Protein		Ash		Fat		Carbohydrates	
Wet %	Dry %	Wet %	Dry %	Wet %	Dry %	Wet %	Dry %	Wet %	Dry %
78.3	21.7	20.2	93.1	1.1	4.9	0.2	1.0	0.2	1.0

No significant amount of water was consumed by bats of either sex during the study. It is, therefore, probable that under conditions where blood is readily available, the vampire does not utilize free water but depends on ingested blood for the necessary moisture.

Table 1 shows the digestibility of the various blood constituents. It demonstrates the high digestibility of the blood protein (93%) as compared to the digestibility of the fat and carbohydrate, indicating that the vampire obtains practically all of its energy from protein. Even more credence is given to this idea by the fact that the average bat consumed 13.4 mls of blood containing 2.91 gms of solid material. Of this, 27.1 gms are protein, 0.03 gms are fat, and 0.03 gms are carbohydrates.

Bats used in this study required an average of 5.31 kcal of net energy per day for maintenance (Table 2). It obtained this energy from the consumption of 15.95 kcals of metabolizable energy. Or in other words, it requires 3 kcals of metabolizable energy for each kilocalorie of net energy required. It is not difficult to visualize that an active bat in the wild would require considerably more blood (protein) for survival, and since 30 out of every 100 kcals of protein are converted to heat during metabolism, the heat dissipation could become quite a problem.

Statistical analysis revealed a highly significant difference between sex in metabolizable energy consumed. This can be explained by the fact that the females were heavier (Table 2) and consumed more blood (Table 1). When the metabolizable energy was put on a per gram body weight basis, the females actually consumed less than the males (Table 2).

Table 3 shows the composition of the blood fed, and again emphasizes the high proportion of protein in the vampire diet.

II. Variation in Concentration of Chemicals on Surface-coated and in Pelleted Baits

A. Introduction

Surface-coated baits often produce erratic and unsatisfactory results in field experiments and pest control programs. Many physiological, nutritional, and ecological factors contribute to this variability. Formulation is also a potentially important factor. Poor success in some recent field experiments prompted an evaluation of the distribution of chemicals among baits.

B. Results and Discussion

A liquid scintillation radioisotope procedure was used for the quantitative determination of DRC-736 (4- [Methylthio]-3,5-xylyl methylcarbamate) in individual baits. The procedure involved the soxhlet extraction of crushed baits and determination of C^{14}-DRC-736 concentration in the extract. Procedural variation (including spiking errors) was less than 5%.

An analysis of individual baits from three surface-coated (cracked corn, wheat, and oat groats) and three tableted (same three materials ground and tableted) formulations showed that the chemical distribution varied over a 5.4-fold concentration range for the surface-coated cracked corn treatment, and 2.5-fold for the surface-coated wheat and oat groat treatments. The tableted baits were much more uniform, the variation being less than 0.1 fold.

Results for surface-coated treatments were similar to those reported in the literature. Field baiting programs involve "batch" preparation in a large mixer and larger variations should occur than were found for the laboratory formulations. Tableted baits offer an alternative for baiting situations where chemical concentration is a critical factor.

A paper describing this phase of research is in the rough draft form. It will be submitted to a scientific journal for publication in 1970.

III. Assessment of the Reinforcing Effects of Food Odor in Rats With Operant Conditioning Techniques

A. Introduction

Odorous compounds which direct rat movements toward a bait and away from established trails, crops, or storage facilities might greatly enhance rodent control programs. Operant conditioning techniques have been reported to be a reliable means of assessing the reinforcing properties of odors.

B. Results and Discussion

Two pilot studies and one experiment were conducted during the calendar year. The results thus far indicate that food odor is not a strong motivating stimulus for food-deprived rats when compared to other traditional reinforcers such as food, water, escape from shock, or introcranial stimulation. The low response rates along with wide variation in response rates between and within animals indicate that these methods are inadequate for the screening and scaling of potential attractants. Either food odor is not a strong attractive odor for domestic rats or operant conditioning procedures are not sensitive enough to reliably measure this attractiveness.

The results of the two pilot studies and the experiment are comparable and Table 4 is representative of the response rates generated by making food odor delivery contingent upon lever pressing. It was noted, however, that food-deprived albino rats respond to food odor twice as great as hooded rats (73.6 vs. 32.1 bar presser/hr) and show less habitation to the food odor on the third day of testing (51.2 vs. 13.5 responses/hr).

Wild Norway rats will be tested in this same situation in order to evaluate the relative contributions of olfaction in the wild rats' food seeking behavior.

TABLE 4. A comparison of the mean response rates per hour for hooded and albino rats when either air or food odor delivery is made contingent upon lever pressing

Day	Air	Odor	Mean difference	S.E. of mean difference
		Hooded Rats		
1	1.5	33.6	32.1	± 13.6
2	4.4	12.8	8.4	± 6.9
3	3.1	16.6	13.5	± 7.1
Total	9.0	63.0	54.0	
		Albino Rats		
1	11.9	85.5	73.6	± 13.3
2	9.6	62.5	52.9	± 9.3
3	10.5	61.7	51.2	± 17.7
Total	32.0	209.7	177.7	

IV. Responses of Rats to Potential Attractant Odors in an Open Field Test--Uniformity Trials

A. Introduction

Odorous compounds which would direct rat movements toward a bait and away from crops or storage facilities might greatly enhance rodent damage control. In order to choose the most effective candidate attractant odors, a method of assessing the reinforcing values of various odors is needed.

Operant conditioning procedures have been used with food-deprived rats in an attempt to assess the reinforcing properties of food odor. The wide variation in response rates between and within animals indicated that these procedures were inadequate for screening and scaling potential attractants. The present study is designed to evaluate a second method (open field test) of measuring preferences for odors.

B. Results and Discussion

The experiment has not been completed and no data are available to report at this time.

V. Taste Preference Instrumentation and Methodology. I. Uniformity Trial.

A. Introduction

Considerable effort has been placed into the development of methodology and instrumentation to measure consumatory preference of rodents for taste and flavor stimuli. As such, five electronic preference testers were designed and built for testing of solid and liquid foods based on the principle of the brief-exposure foods-together technique. The foods-together technique is reported in the literature to be one of the best behavioral methods of measuring taste preference because it is rapid, sensitive, and minimizes position habits. The present uniformity trial was conducted with 38 black hooded rats to measure positional effects and the variation among individual rats treated alike.

B. Results and Discussion

The results are presented and discussed in a paper entitled "Electronic Preference Testing Apparatus for Rating Palatability of Solid Foods." The manuscript is in the rough draft form and will be published in 1970.

VI. Experiments in Taste Preference Methodology With Rodents. I. Preference For Positive and Negative Taste Stimuli in Different Solid Food Formulations

A. Introduction

There is a need in the field of rodent control for knowledge of the consumatory preference of rodents for a broad spectrum of taste stimuli in solid food media. Heretofore, we have been hampered in obtaining such knowledge because of the lack of suitable preference testing instrumentation and methodology. This study was designed to measure preference behavior of rodents to positive and negative taste stimuli in different solid food formulations.

B. Results and Discussion

The specific objectives of this study are:

1. Measure preference of rats for different concentrations of sucrose (0% to 100%) in tablet form.

2. Measure the effect of food particle size on consumatory preference of rodents for negative taste stimuli.

3. Measure the consumption enhancement strength of selected taste and flavor stimuli when added to natural food.

Objective 1 has been achieved. The results are presented in a paper entitled "Electronic Preference Testing Apparatus for Rating Palatability of Solid Foods." The paper is in the rough draft form and will be published in 1970.

Objective 2 was also achieved by presenting rats with a choice between untreated wheat (standard) and wheat containing quinine hydrochloride and tributyltin benzoate (treatments). Preference of each negative taste stimulus was measured separately in wheat pellets made of 4, 10, 20, 30, 40, 50, and 60 mesh size particles. Particle size of each standard was identical to the test food. The mean results are presented in Table 5.

TABLE 5. Consumatory preference response of laboratory rats to negative taste stimuli on seven different sizes of food particles

Particle size (mesh #1)	No. of animals	% Preference	
		Quinine Hcl	Tributyltin benzoate
4	6	13.7	49.0
10	6	4.8	32.2
20	6	2.9	3.7
30	6	4.2	2.0
40	6	4.9	0.6
50	6	9.5	12.8
60	6	1.8	4.8

While the data have not been statistically analyzed it is obvious that rats showed less aversion to the stimuli on the larger food particles.

Objective 3 of this study has not been completed. This phase will continue indefinitely.

VII. Physiological and Behavioral Response of Red-winged Blackbirds to DRC-736. I. Role of Stomach Fill and Formulation on Variation in Response.

A. Introduction

Field studies conducted by Denver Wildlife Research Center biologists show that an immobilizing drug, DRC-736, is an effective area repellent for red-winged blackbirds in feedlots in the South Platte River Valley in Colorado, and has potential for this use in other areas of the U. S. However, a serious problem exists in its widespread use since there has been a large variation in the percentage of birds immobilized when the chemical is formulated on cracked corn (1% to 4% by weight) and applied to blackbird populations in California, Oklahoma, South Dakota, Colorado, Texas, and Arizona. Denver biologist need

to know whether this wide variation in response to a given formulation of DRC-736 is due to a difference in physiological susceptibility of bird populations from region to region or merely to physical factors related to formulation and baiting, and to the amount of food individual birds have ingested prior to taking a treated bait.

B. Results and Discussion

This study was conducted with 20 red-winged blackbirds to achieve the following objective:

1. Measure the variation in physiological and behavioral responses to DRC-736 when administered on cracked corn and in precision tablets of corn on an empty and full stomach.

The objective of the experiment has been achieved. Data will be published during calendar year 1970.

REPRODUCTION - J. J. Kennelly, M. V. Garrison, B. E. Johns, and J. D. Roberts

I. Rodent Reproductive Studies and Evaluation of Candidate Chemosterilants

Spermatogenic Cycle of Polynesian Rats

A. Introduction

A study of the spermatogenic cycle and duration of epididymal sperm transport was undertaken as part of a major study of the reproductive patterns of Polynesian rats. The general objective was to establish criteria whereby the selection and evaluation of male antifertility compounds could be accomplished. The specific objectives of this phase of the work were (1) to define the duration of the spermatogenic cycle and its major subdivisions, (2) to define and estimate the duration of the stages of the spermatogenic cycle, and (3) to establish the time required for epididymal sperm transport.

B. Results and Discussion

Additional animals were required to complete the study; evaluation of the tissue from these animals is not yet complete. Analysis of the data and preparation of the manuscript will be completed in 1970 with publication most likely in 1971.

Tests of Antifertility Compounds

1. DRC-1810

A. Introduction

This male chemosterilant is reported to irreversibly damage the seminiferous tubules in laboratory rats rendering treated animals sterile. The chemical appeared to show sufficient promise to warrant further tests with a target species.

B. Results and Discussion

A manuscript of the work has been prepared for the Journal of Reproduction and Fertility and publication of the work is expected in 1970.

2. DRC-4800 (U-5897)

A. Introduction

U-5897 produces permanent sterility in both laboratory and Norway rats. Tests were conducted to determine the potential use of this compound for the control of Polynesian, rice field, and black rats.

B. Results and Discussion

A manuscript of the work has been prepared for the Journal of Wildlife Management and submitted to Washington, D. C., for approval.

Nutrition Studies - Polynesian Rat

A. Introduction

Although sugarcane damage by Polynesian rats is well established, it is uncertain whether the animals damage the cane in seeking a source of food or if the sugarcane is an "enjoyable" supplement to the diet. Further, the high fiber content of sugarcane raises the question of how nutritious and digestible the cane is. Accordingly, a study was initiated to (1) determine the digestion coefficients of the major constituents of sugarcane, and (2) determine the effects of diet on the digestion coefficients.

B. Results and Discussion

A manuscript has been submitted to the Journal of Wildlife Management.

Detection of Postpartum Estrus in Polynesian Rats

A. Introduction

As part of an ongoing program to establish the normal reproductive pattern of female Polynesian rats, a study to detect the occurrence, if any, of a postpartum estrous period followed by delayed implantation was undertaken. If postpartum heat and/or delayed implantation occurs in this species, it will have a direct bearing on the selection of antifertility compounds and the design of tests undertaken to evaluate such compounds.

B. Results and Discussion

The results of the postpartum breeding tests are shown in Table 1.

TABLE 1. Results of postpartum breeding study with Polynesian rats

Number of females	Mean gestation period (days)	Mean litter size	Number of females exhibiting postpartum estrus	Number of females bred to males	Number of ova recovered: cleaved	Number of ova recovered: total
6	22.2	3.2	6	6	16	21

The Polynesian rat does breed and conceive within 48 hours of having a litter. Litter size is small, averaging 3.2 young per litter (range 1-6). Most of the ova recovered were cleaved indicating the female is quite fertile. The data also showed that delayed implantation occurs following a postpartum fertile mating when the females are nursing at least three young. Studies are in progress to determine the absolute minimum number of nursing young to initiate the delayed implantation reaction.

Control of Wild Rodent Populations via Reproductive Inhibitors

1. Testing the Concept of a Permanent Male Chemosterilant

A. Introduction

The concept of a permanent male chemosterilant for rodent control, although advocated by many, has never been tested. The current study was designed to test this concept through the use of colony studies of Norway rats in which a predetermined percentage of males in one colony is surgically sterilized and compared with a control colony.

B. Results and Discussion

The treated and control colonies were established in December 1969. The study will be terminated in April 1970 and the results presented in the 1970 Annual Progress Report.

ELECTRONICS - E. W. Pearson, G. W. Corner, H. D. Walkup, J. O. Ells, and A. L. Kolz

I. Miniaturization and Construction of Transmitters for Small Animals

A. Introduction

Radio-tracking techniques have been used since 1963 by a growing number of personnel at this Center to assist in wildlife investigations. Since electronically trained personnel have been assigned to assist them by finding or developing electronic tools, it seemed logical that assistance should first be given to those who needed to initially begin telemetry studies. Their problems included the necessity for miniaturization of transmitters, so much of our effort has been directed toward finding small components, then developing techniques to work with them.

B. Results and Discussion

Several segments of miniaturization and related construction techniques have received considerable attention, and they will be discussed separately.

In last year's more general annual report (Work Unit DF-101.4), we related the development of a portable 30 MHz (megahertz) radio-tracking receiver. A manuscript describing the receiver has been written and submitted for publication.

Also in last year's annual report (Ibid.), we briefly described the laboratory development of a miniature collar transmitter for use on rats, gophers, and other small animals. This contained a miniature crystal which we thought was the ultimate in refinement of size and performance, but it actually was not centered on our frequencies; we tested two more prototypes (the sixth and seventh) before the performance was satisfactory.

Several distance and performance tests were run which indicated that besides miniaturization, transmitter lives have been more than doubled, from 12-15 days to 27-30 days. Two transmitters used on ground squirrels at the best physical collar fit were resoldered for near optimum

electronic "fit" and ran for 53 and 69 days in the laboratory, and 45 and 66 days exposed to fall and winter weather conditions. The design of these transmitters was provided to a retired California electronic engineer who is now building the required quantities for the Hawaii and Philippine research stations. During the past year, 115 of the old, large design, and 64 of the new miniature rat transmitters were delivered to Hawaii and the Philippines research stations, and 86 more are being commercially constructed to send to these field stations. To the present, all commercially-built transmitters have been checked for several parameters in this laboratory before release to field stations.

In addition to those miniature transmitters provided for use on rats, about 55 more were laboratory-constructed for other purposes. These included about 20 for laboratory and local field tests, 6 for use on red squirrels in Montana, 10 for pack rats in Texas, and 20 for small pocket gophers in the Northwest.

A major effort this year was directed towards rebuilding the miniature transmitter with whip antenna that is used on birds, and to adapt it for use on bats, using the new miniature crystal and transistor. The recently hired electronic engineer was of major assistance in the several phases of this redesign problem, which resulted in a slightly larger transmitter than first anticipated, but one with increased stability and signal output and decreased power drain. It now weighs about 1.6 g without a battery compared to about 2.6 for its larger predecessor. About 25 transmitters of the new design have been built for laboratory tests and for use on penned bats and birds, and about the same number are being constructed for field use on starlings in the Northwest and on vampire bats in Mexico using three different methods of attachment. These are normally powered by the No. 675, 1.4-volt battery which weighs 2.2 g.

Pen tests are being conducted to determine the optimum size of wire to use as whip antennas on starling transmitters, and it appears that a .015-inch guitar string will be adequate. On dummy transmitters on starlings in a nylon netting pen, .010-inch diameter flexible wire broke after an average of 4.8 days (range, 2-7) on 5 birds, .012-inch diameter guitar string antennas broke after an average of 21.7 days (range, 7-26) on 7 birds, and 6 of .015-inch diameter were still unbroken after an average of 31 days (range, 4-64) in continuing tests.

Two field trips, one to Oregon in January, and one to Mexico in April, aided in the development of the transmitter with whip antenna. Working with personnel in the Section of Birds in Oregon, 24 chemically treated starlings were fitted with 8-g (two-battery) transmitters of the large crystal size,

and released back into their holly orchard roost; nine (37.5%) were recovered in the roost in the first 42 hours following dosing and release, and three more were recovered within 3/4 mile of the roost. From a 20% sample search, it appeared that about 20% of 275 noninstrumented, but dosed, starlings died in the roost, indicating that 8-g transmitters may affect starling movements to some degree.

In April, a Fairchild Digital Frequency Meter, Model 8220, was purchased and used with our Hewlett Packard VHF Signal Generator to locate and correct two major problems in telemetry development. One was the miniature crystal frequency problem described briefly earlier in this report, where it was discovered that transmitters built with the new crystals were not oscillating at the center of the frequency for which they were designed. At about the same time, we discovered that our E. F. Johnson 350/DF receivers were not aligned properly on all channels. Eleven of the 14 receivers have been received from the purchasers (mostly from field stations), their receive frequencies centered on each channel, then returned to the owners. We can now be confident that each transmitter built or checked through this laboratory will be received correctly on each channel of each 350/DF receiver that has been properly aligned. It appears that the Signal Generator and Frequency Meter, although expensive, have probably "paid for themselves" in the first 1-1/2 years of use.

Power supplies, including batteries used on receivers and small mercury cells used on transmitters, have been more closely scrutinized this year. The voltage of the battery that powers the receiver is more important than previously realized in obtaining the greatest receiving sensitivity. Specifications show that the 350/DF will operate on 13.8 volts, ±20% or in a range of 11.04 to 16.56 volts. The meters on two different Messenger 350/DF receivers that were used with several batteries determined the variations of the received signal. The same antenna was used in each test situation with the signal coming from the same transmitter set about 150 ft away. In one test, a battery that measured 12.0 volts indicated a received signal strength of 4.0 db (decibels); with a 14.3-volt battery powering the receiver at the same control settings, the received signal strength increased to 6.5 db. In another test with a second receiver powered by 11.8 volts, then 14.3 volts, the received signal levels were 4.0 and 7.2 db, respectively. In other words, an additional 2.3 and 2.5 volts increased the received signal levels by 2.5 and 3.2 db, a most welcomed addition at marginal receiving distances. Batteries available are the Eveready No. 564 at 13.5 volts, and Eveready No. 561 at 15 volts (or equivalents made by other companies), with the latter the heavier by about 1/2 lb).

During routine laboratory and limited local field tests, we found that lives of small batteries used to power miniature transmitters varied considerably. The shelf life of each size of battery apparently is fairly uniform, but the unknown is the length of time batteries have been on the local dealer's shelf. We now order the two sizes, No. 625T2 and No. 675T2, for miniature collar and whip antenna transmitters, respectively, directly from the factory and have had little variation in transmitter lives from varying voltage problems. Batteries are also constantly refrigerated after reciept, and two batteries from the same order powered the same transmitter 69 and 66 days on consecutive tests, and in similar tests, another transmitter ran 42 and 45 days. By ordering directly from the factory, we also found that the No. 625 battery with soldering tabs was available at 1.40 volts and 350 mah life; previously those with tabs were only available locally in the 1.35 volts and 250 mah configuration. The slightly increased power, greatly increased life, and presence of tabs to dissipate heat while soldering are all benefits from factory orders. The 350 mah battery weighs 4.50 g, with tabs, compared with 4.25 for the 250 mah battery.

Unprotected solar cell chips have continued to power a 1.4-volt transmitter uninterruptedly on the laboratory roof during daylight hours since June 1967. A small 1.4-volt mercury battery, the RM 312, powered a transmitter for about 3 days, as expected. When an RM 312 was connected to recharging circuitry that was attached to solar cell chips, the transmitter (battery) life was extended to 26 days. Further tests to determine the practical utility of solar cells in telemetry applications have been started in the laboratory environment.

C. Conclusions

After seven prototypes were tested (five in 1968), and an order for miniature crystals was received, these and a miniature transistor were worked into the design for a miniature collar transmitter for rats and gophers. About 55 transmitters were constructed in the laboratory for experimental purposes and for limited field use in Montana, Texas, and Washington. About 115 of the old, large rat transmitter design and 64 of the miniature transmitters have been commercially built under our direction, checked for performance, then sent to field stations in Hawaii and the Philippines; 86 more are being commercially-constructed.

Using the new miniature crystal and transistor, the task of redesigning the miniature transmitter for use on small birds and vampire bats has progressed to the point where laboratory and pen tests are underway, and tests on released birds will begin soon. About 25 have been laboratory-constructed for experimental use, and a similar number are being built for field tests in the U.S. and at the vampire bat field station in Mexico.

Pen tests that are nearly completed indicate that the flexible guitar string whip antenna for miniature transmitter use on starlings must be at least .015 inches in diameter.

A problem of frequency alignment in receivers was discovered and corrected, and control of frequencies during transmitter construction were aided immeasurably by the use of our Hewlett Packard VHF Signal Generator and newly purchased Fairchild Digital Frequency Meter.

II. Comparison of 30 MHz vs. 164 MHz Frequencies for Radio-Tracking Studies

A. Introduction

Personnel at this Center have used assigned radio-tracking frequencies in the 30 MHz frequency band almost exclusively, but others have successfully used frequencies in the 148-151 MHz range, which are comparable to our recently assigned 164 MHz frequencies. Present radio-tracking workers do not agree on the merits of each for the various situations encountered in wildlife tracking studies; they both should be thoroughly investigated in order to use both time and money most efficiently in future studies. Ideally, the optimum frequency should be investigated for several species including those living underground, on the earth's surface, in trees, and those that fly; also those that live in a wet or dry climate, in mountains or plains, and in forested or open habitat.

B. Results and Discussion

Throughout the descriptions in this report, the equipment used in all tests was the same for each frequency range. The transmitters were of the whip antenna configuation and had been built in this laboratory unless otherwise stated. Power supplies for transmitters varied, and voltages will be given for each test situation.

The 30 MHz receiver was an E. F. Johnson Company Messenger 350/DF redesigned specifically for radio-tracking on our assigned frequencies (1968 Annual Report, Work Unit DF-101.4). The 164 MHz receiver was constructed for use on our frequencies by the AVM Instrument Company (W. W. Cochran), and its receiving sensitivity was lower than that of the 30 MHz receiver. However, the lower sensitivity was more than offset by the great imbalance of the receiving antennas that could practically be used in the field. A hand-held directional antenna is a necessity for wildlife radio-tracking, so that configuration was used in all comparison tests. The imbalance occurs because a far more efficient directional, hand-held antenna can be built for use in receiving 164 MHz than 30 MHz frequencies. In addition,

the transmitter's antenna is comparably more efficient on 164 MHz. In other words, while both the 164 MHz transmitters and receiving antennas are more efficient because the antennas of both are more nearly equal to their radio wave length, the measurements described are very similar to those that would be expected under the conditions that would be encountered in wildlife radio-tracking.

The tests conducted would fall into three general categories, tests of signal reception through vegetation and through the earth, and tests including both obstacles. In Mexico, tests through vegetation and from caves generally indicated that 30 MHz would probably be superior to 164 MHz for most vampire bat work, although 164 MHz would be much more efficient for use in primarily open areas permitting line-of-sight reception.

In three mines in Colorado, 30 MHz was superior to 164 MHz in two mines, and the configuration of the third mine may have produced a resonant cavity trap that allowed 164 MHz to outperform 30 MHz (this possibility confirmed by Dr. James Lindsay, School of Mines, Golden, Colorado). In one mine with railroad tracks and power line, the insulated power line acted as an RF (radio frequency) conductor, but the tracks did not, probably because they were grounded. In the only nearby cave that we could locate, 30 MHz outperformed 164, but in none of these tests was either frequency even adequate for radio-tracking both underground and in uneven terrain with heavy vegetation.

In limited Colorado tests over uneven terrain and in conifer forests, test results were varied and inconclusive. In February, signals from transmitters of both 30 and 164 MHz frequencies could be received over a sharp, 450-ft high ridge, but using the same equipment in July, neither could be received when placed in the same sites. Similar changes in performance occurred several times at different seasons of the year with only 30 MHz equipment involved.

C. Conclusions

1. Brief comparison tests in Mexico and Colorado indicate that as expected, 30 MHz frequencies are superior to 164 MHz frequencies in caves, but that neither is really adequate for work underground.

2. Varying results in the same test situations at different seasons of the year indicate that more stringent tests in specific sites will have to be conducted, and perhaps for each specific species in its own radio-tracking environment.

III. Receiving Antenna Systems for 30 and 164 MHz Frequencies

This work segment was nearly inactive this year, and no noteworthy results have been recorded.

IV. Laboratory Screening to Find Sounds Frightening to Starlings

A. Introduction

While many, or most, bird problems can be alleviated by the use of chemicals or other lethal or repellent devices, some situations have arisen where these are impossible or impractical to use. Sound appears to be a useful tool to repel starlings, and it further appears that laboratory screening of sounds will be the most practical method to use to find the most effective sounds for field evaluation.

B. Results and Discussion

The construction of two chambers for testing starlings with broadcast sounds was completed, and duplicated tests with three calls indicated that acoustical construction goals were adequately achieved. Problems of locating an acoustically wide-band small speaker, reducing excess heat from the lighting system, and reducing excess noise from the circulation fan were overcome. A nylon netting cage with wooden framework and perch was made for each chamber and enclosed a hexagonal area within the chamber where sound tests indicated the least variation in broadcast sounds of 500 to 10,000 cycles per second. After the initial trials with 15 starlings proved the chambers' acoustical testing capabilities, the planned sound screening program was not initiated because the assigned principal investigator transferred out of this Unit.

C. Conclusion

Although an acoustically-correct bird test environment has been constructed or otherwise established, the transfer of the assigned principal investigator out of this Unit apparently means the cancellation of sound testing described in the appropriately named Study Plan.

BIRD DAMAGE CONTROL RESEARCH

LATIN AMERICA - J. F. Besser and J. W. De Grazio

A. Introduction

Surveys of agricultural bird problems in Latin America, begun in June 1968, were continued in 1969 with visits to Colombia, Costa Rica, Honduras, Mexico, Nicaragua, and Venezuela under the agreement with the Agency for International Development, U.S. Department of State. Crop-growing areas were visited in the Magdalena and Cauca Valleys of Colombia; the Nicoyan Peninsula of Costa Rica; the Sula and Chamelecon Valleys of Honduras; the States of Guanajuato, Jalisco, Michoacan, and Queretaro in Mexico; the Leon area of Nicaragua; and the States of Aragua, Carabobo, Cojedos, and Portugesa in Venezuela.

Several studies of specific problems were initiated in cooperation with scientists of Latin America. Study was begun of the parakeet problem in grain sorghum plantings in the vicinity of Leon, Nicaragua; of the dove problem on emerging soybeans in the Cauca Valley; and at year's end, preparations were being made to attempt to reduce damage caused by dickcissels in Venezuela.

Chemical damage control agents were cage tested on a variety of species of birds in Latin America and on some U.S. species that are closely related to some of the most troublesome ones in Latin America. Fright-producing agents, immobilizing agents, and toxicants were the type of chemicals appraised.

Laboratory development of some of the information that will be necessary to safely use chemical agents in Latin America was begun or continued in conjunction with U.S. work on these chemicals for the same crops and families of birds attacking them. Major emphasis in these studies this year was on finding microanalytical methods for determining presence and amount of residues in plants and soils and the possible translocation of specific agents into specific crops requiring bird protection.

B. Results, Discussions and Conclusions

Bird Damage Survey

Grain sorghum, corn, and rice were the crops most frequently found damaged. Other crops attacked were soybeans, fruits, wheat, and cacao. Various species of the icterid, fringillid, psittid, columbid,

and anatid familes caused most of the damage. These crops, the birds observed feeding in them, and possible control methods applicable to them are reviewed as follows:

Grain Sorghum

Grain sorghum appears to be a favorite food of bird populations wintering in Latin America. In Venezuela, large numbers of dickcissels (Spiza americana) largely consumed a grain sorghum planting near Acarigua. Flightlines of about 75,000 dickcissels were observed on the evening of January 25, 1969, at a time when local informants reported that the dickcissel population had "cleaned up most of the crops and migrated south." Those collected had fed on grain sorghum. In February, smaller-sized fringillids were in almost every sorghum field visited in both Colombia and Venezuela. Few were in sorghum fields in Costa Rica, Honduras, and Mexico in areas where many breeding pairs had been noted the preceding June, indicating a major migration to more southerly latitudes. The ruddy-breasted seedeater (Sporophila minuta) was the commonest species, occurring in groups of several to several dozen individuals. They were usually accompanied by blue-black grassquits (Volatinia jacarina) and less frequently by yellow grass finches (Sicalis luteola) and wedge-tailed grass finches (Emberizoides herbicola), all of which are collectively termed "chisquas" by farmers. Female ruddy-breasted seedeaters taken in nets and traps in Colombia weighed as little as 6 g, and it is difficult to visualize that such small birds could cause major damage, but damage by "chisquas" was readily apparent along the borders of several fields inspected closely where there were grain sorghum varieties with low tannin content. At several experimental station plots "chisquas" combined with parrotlets and parakeets appeared to make sorghum yield more a function of a variety's resistance than its yield capacity. Volatinias were noted breeding in grain sorghum fields in Nicaragua in June. Lark sparrows (Chondestes grammacus), sometimes in the hundreds, were observed feeding in harvested sorghum fields in Mexico.

Predicting damage by fringillids is complicated by the fact that their diet before cultivated cereals were introduced must have been native grass seeds. The supply of these (perhaps preferred) foods probably varies considerably with climatic conditions on the savannahs adjacent to the cultivated areas; when wild grass seeds are scarce, more damage probably occurs. Another difficulty in estimating the amount of damage by small birds is related to their size. For example, damage by parrots and doves may be overemphasized, while damage by small flocks of small birds goes relatively unnoticed. Similarly, damage by large flocks of small birds may be noted much more readily than greater damage by a large number of insects (or by disease).

Psittids also appear to favor grain sorghum fields. Parrotlets of the genus Forpus were flushed from many sorghum fields in Colombia; parakeets of the genus Aratinga were seen in several Venezuelan fields; and about 200 red-lored parrots (Amazona autumnalis) were observed being herded by rifle fire from the only sorghum field noted near Puntarenas, Costa Rica. Attacks by psittids and other bird species may prevent expanded culture of grain sorghum, particularly those varieties with low tannin levels, which appear the most palatable both to cattle and to birds. Parakeets are a perennial problem in the vicinity of Leon, Nicaragua.

Doves, primarily resident species, are a very widespread, though usually minor, problem in Latin America. However, damage by the white-winged dove (Zenaida asiatica) and eared dove (Zenaida auriculata) is locally serious. These doves, unlike the mourning dove (Zenaidura macroura) of North America, alight and feed on heads of standing grain. About 500 whitewings were seen feeding in a grain sorghum field near Leon, Nicaragua. Doves were also reported to cause damage in the Sinu Valley of Colombia, both at planting time in May and September and after the grain matured in August and September. Cottom and Trefethen (1968) reported that whitewings also damaged grain sorghum fields in Mexico.

Blackbirds were reported to be a major problem in October and November in grain sorghum fields in the highland plateau states of Mexico. When this area was visited in later February, all the sorghum crops had been harvested, but flocks of 10,000 to 100,000 blackbirds gleaning fields were frequently seen wherever large rivers or lakes provided suitable roosting habitats. Yellow-headed blackbirds (Xanthocephalus xanthocephalus) were the most heavily concentrated in the Lake Yuriria area of Guanajuato, along the Rio Lerma in Michoacan, and near Lake Chapala in Jalisco. Brief discussions with farmers indicated that the yellowhead is troublesome in October and November and at planting time in March. Brown-headed cowbirds (Molothrus ater) were especially numerous, and flocks of 5,000 to 50,000 were commonly noted gleaning grain sorghum fields in the states of Guanajuato, Michoacan, and Queretaro. Boat-tailed grackles (Cassidix mexicanus) in flocks numbering up to a thousand or more were encountered in sorghum fields near many cities and towns in Mexico.

Chemical frightening agents would seem to be an excellent answer for many of the bird problems in grain sorghum, because these agents are far more effective in clearing fields where thousands of birds are feeding than where there are only small groups (Woronecki et al, 1967).

Generally, methods for reducing crop damage by fringillids have been ineffective. Members of this family are not very responsive to mechanical frightening methods and patrolling, although both have been regularly tried. Perhaps chemical frightening agents, which rely on behavioral responses of unaffected birds, would be more effective, and even decoy trapping of species that are highly gregarious (as most of them are) may have value.

In the areas visited, the present methods of protecting sorghum from psittid damage are patrolling and the use of gas-powered cannons. Patrolling is apparently quite effective for small fields of several hectares; and where a very inexpensive labor supply is available, this is perhaps the most effective method at this time. However, patrolling is both less effective and more costly for large fields, and improved methods of reducing damage are needed. The gregarious nature of members of this family and their highly developed communication system should make them responsive to chemical frightening agents, amplified distress or alarm calls, and even perhaps to decoy trapping. These measures may possibly afford substantial protection at low cost.

Generally, sport hunting and utilization of the birds for food is the preferred method of alleviating damage by white-winged and eared doves. However, in areas where the eared doves are especially abundant, an occasional grower has resorted to poisoning. In one case reported, the grower was fined for this practice, but he believed the fine was far less than the benefits received from the reduction of dove damage to his crop.

Chemical repellents, patrolling, and gas-powered cannons have been tried for reducing damage by blackbirds. Chemical bird repellents have been reported to be somewhat effective in Mexico against damage to germinating grains (Young and Zevallos, 1960), but none of the more effective, recently discovered bird repellents, such as DRC-736 (West et al, 1969), have been tried. In Honduras, the patrolling of newly seeded fields by small boys was reported to be fairly effective, and perhaps it would be difficult to improve on this method when an abundant labor supply is available.

An approach to the bird problem in sorghum with far-reaching implications is the planting of high-tannin, bird-resistant varieties. In Venezuela, a planting of a resistant sorghum, AKS-614, was viewed that had escaped damage by dickcissels and that yielded nearly as well as the commonly planted African variety, Swasi. A nearby planting of Swasi had been nearly destroyed by dickcissels. Colombian agronomists also reported that one of their new high-yielding varieties, P-25, appears to be less susceptible to bird damage. Honduran

agronomists were less enthusiastic about this approach, stating that their bird-resistant variety, DKBR-47, was useful when other foods were available but was taken when other foods were scarce.

Corn

The discovery of the benefits of high-lysine corn, Opaque 2, in the cure and prevention of severe cases of human malnutrition (D.D. Harpstad, personal communication) increases the importance of bird problems in this crop. It is anticipated that new crop areas will be cleared from present jungle and brush habitats, and that these will be subject to increased bird pressure. Many of the present intensively cultivated valleys have been largely cleared of the wolf trees that are necessary for parrot breeding, so that now only corn areas adjacent to foothills are extensively damaged. With the increased acreage in habitats more vulnerable to bird damage, corn protection methods now being successfully developed in the United States (De Grazio, 1964; Woronecki et al, 1967) would also appear to have special value in Latin America.

In February, most cornfields had been harvested in the areas visited, or were in early nonvulnerable growth stages. However, in the few fields where corn was in the milk, dough, and dent stages, species of parrots and blackbirds were certainly attracted. One farm near Progreso, Honduras, near the Ulua River, had small numbers of "chekos" (an unidentified woodpecker), red-winged blackbirds (Agelaius phoeniceus), and white-crowned parrots (Pionus senilus) all feeding on corn in the same field at one time. The "chekos" were stripping the husks and feeding on the ears in the milk and dough stages, and the parrots were cutting into the more mature ears. This type of damage by parrots, parakeets, and parrotlets was reported to be more serious in the Choluteca and Comayagua areas of Honduras than in the Sula Valley and probably occurs in many corn-growing areas in Latin America.

Lack of adequate storage and drying facilities in these humid areas prolong the damage period. Psittid attack on corn allows moisture to enter the ear and increases spoilage, and the damaged ears become more vulnerable to subsequent attack by smaller birds that are unable to open the ears easily themselves.

Damage by boat-tailed grackles to emerging corn seedlings was commonly reported in Honduras and Mexico. Skutch (1954) reports that boattails greedily tear up sprouting corn in newly planted fields and gave an example of one Guatamalan farmer's frustrated efforts in starting a cornfield. Young and Zevallos (1960) also reported that brown-headed

cowbirds and boattails cause serious damage to sprouting corn in winter in tropical Mexico. Chemical repellents were an acceptable answer to a similar problem in Texas (West and Dunks, 1969).

Chemical frightening agents also appear to be an excellent answer for many of the bird problems in corn. Mechanical frightening methods, patrols, and trapping may also be effective.

Rice

The dickcissel was frequently implicated in rice damage in Costa Rica, Venezuela, and Colombia. In Costa Rica, Slud (1964) describes it as "the supreme pest of the rice fields," and also states that "it arrives like a plague from foreign parts as the rice ripens." Depredations in Costa Rica take place from September to November. In Trinidad, Ffrench (1967) reports the chief food of dickcissels is rice left in the fields; and in Venezuela, Rohl (1959) states they cause "enormous ruin" in rice fields and growers consider them a virtual plague.

Bobolinks (Dolichonyx oryzivorus) were regularly mentioned as a species of increasing economic importance in rice culture, particularly during the period of their return migration to the United States and Canada during April and May. It was the consensus of Venezuelan scientists that bobolinks are increasing, and this was borne out by a documented report from a rice-growing area near Carro Seco in the State of Portuguesa, where bobolinks destroyed 30% of an 80-hectare planting in mid-May 1968.

Although rice has a reputation for being severely damaged by birds, fewer birds were generally seen in ripening rice fields than in grain sorghum fields nearby. In the Tolima sector of the Magdalena Valley, one of the chief rice-growing areas in Colombia, where rice fields were being harvested and planted, substantial flights of birds were absent during the evening hours when birds are usually the most active, taking their final meal and going to roost.

Small numbers of fringillids, particularly the blue-black grassquit, were present in many rice fields in Colombia. In this country, doves were present on most newly seeded fields, particularly the ruddy ground dove (Columbigallina talpacoti), but also eared doves and doves of the genus Leptotila. One such field near Ginebra in the Cauca Valley of Colombia contained about 500 doves, mostly ground doves. Information on the extent and seriousness of doves feeding in standing rice was vague, but small flocks of eared doves were quite common in the Calabozo rice-growing district on the llanos of Venezuela.

Experiment stations growing rice out of phase with commercial production appeared to be especially vulnerable and to receive an inordinate amount of damage. On one such experiment station near Palmira in the Cauca Valley, shiny cowbirds (Molothrus bonariensis), ruddy ground doves, ruddy-breasted seedeaters, yellow grass finches, blue-black grassquits, and red-breasted blackbirds (Leistes militaria) were trapped and netted. Although fringillids were the most numerous, the most damage was caused by shiny cowbirds.

Tree ducks (Dendrocygna sp.) cause locally serious problems in rice fields in Venezuela and Surinam. The white-faced tree duck (D. vidauta) which formerly bred in the small ponds in the llanos, has adapted to breeding and feeding extensively in irrigated rice fields, and complaints by rice growers are increasing. Venezuelan biologists are just beginning to gather pertinent ecological data on this species. The problem has become so severe that rice growers in the Calabozo district of Venezuela requested and obtained a special-permit hunting season on the ducks from May 17 to July 31. Venezuelan biologists have evidence indicating this period covers the peak of their breeding season.

Many blue-winged teal (Anas discors) winter in Lake Maracaibo region of Venezuela and are reported to cause some problems in rice. However, they have been reported to be less wary than the resident species of ducks, and the number of band returns from teal banded in the United States and Canada would tend to confirm this. Problems with migrant ducks in rice were also reported in Mexico.

Sport hunting is the method usually recommended to reduce waterfowl damage. Gas-powered cannons (exploders) are finding increasing favor among rice growers; one Venezuelan rice grower interviewed stated that one of these cannons adequately protected 40 hectares (90 acres) of newly planted rice--truly amazing coverage, but perhaps understandable where hunting pressure is intense and prolonged, serving to reinforce the cannon noise.

Newly discovered chemical repellents will probably have much use for the protection of seeded rice. Patrolling is the only practical means at present to reduce bird damage on ripening rice.

Other Crops

Bird damage to other crops was reported to be more localized. Scattered reports of substantial damage by Andean sparrows (*Zonotrichia capensis*) to emerging wheat seedlings in the State of Cundinamarca, Colombia, were obtained. In Honduras, some planting of wheat is done before the rains, and because the ground is quite hard at this time, white-wing doves eat many seeds not adequately covered.

Eared doves cause substantial damage to germinating soybeans in the upper Cauca Valley, Colombia, by grazing the cotyledons as they emerge from the soil.

Parrots and orioles were reported to damage mangoes in Honduras, and parrots were also reported to damage mangoes in Sinaloa, Mexico. Brown jays (*Psilorhinus mexicanus*) were reported to damage fruits in Costa Rica. Scattered reports of woodpeckers damaging cacao pods on the Caribbean coast in Costa Rica and in the State of Chiapas, Mexico, were also obtained. Orpendolas were reported to damage fruits on the north coast of Venezuela.

Summary

Although Latin American bird habitats are uniquer, the crops attacked and the plant growth stages damaged are quite similar to those commonly encountered in the United States. Even the resident species of birds that cause problems, with the exception of psittids, usually belong to genera of birds that reside in or visit the United States, and sometimes exhibit some of the same destructive habits. Because there are more similarities than dissimilarities in the bird problems of Latin America and the United States, bird damage research conducted in one area should have significant value for farmers in the other, and that cooperative studies by Latin American and United States scientists on some of the problems should be mutually rewarding.

II. Study of Specific Problems

Parakeet Damage to Grain Sorghum

In June, the parakeet-grain sorghum problem was investigated near Leon, Nicaragua. Some of the findings of this investigation were as follows:

1. The species of parakeet causing damage in the Leon area is the orange-fronted parakeet (*Aratinga canicularis*) (Slud, 1964).

2. Parakeets seldom, if ever, fed on the ground, and did not take the outer coatings of sorghum seeds while feeding. They cracked the seed, extracted the meal (preferring the doughy centers) and discarded the tannin-containing outer covering. This will make it necessary to use very high levels of chemicals in order for parakeets to obtain the desired amount of chemicals.

3. Orangefronts caused substantial damage to sorghum per individual. Fasted birds weighed 68 g, those captured in the afternoon, 78 g. Coupled with their method of feeding, "mealing the kernels," a loss of 30% to 40% of the weight of the bird can be expected daily.

4. Orangefronts were apparently traveling long distances from their roost to feed in sorghum fields. The first birds arrived almost 1 hour after daylight and left nearly 2 hours before dark. At conjectured flight speeds, this places the roost 20 to 60 miles from the feeding area. A few flocks were tracked for about 5 miles in a northeasterly direction toward roadless volcano regions.

5. Parakeets were netted with extreme ease; 23 of a flock of about 200 birds were caught in two nets in 2 hours. A decoy left in the net caused "mobbing" and birds were easily tethered to attract others. Broadcasting calls were used to attract birds into nets also.

6. Parakeets were very reactive to vocalizations, a flock of 10 more so than a flock of 200, possibly because the larger groups are so noisy they fail to hear broadcast calls.

7. Parakeets were strongly attracted but not so strongly repelled by broadcast distress calls. A call obtained by dosing a bird with 4-aminopyridine (4-AP), a chemical frightening agent (5), resulted in the most "mobbing." A true distress call obtained by pestering a netted bird appeared to cause birds to move farther from the source of call than the 4-AP call.

8. Effects of distress calls waned relatively rapidly, as did the positive effects of carbide exploders. The effective range of the low-volume call that we used decreased from 150-200 yards on the first day to about 75 yards on the fourth day. The more attractant 4-AP call initially attracted birds up to 300 yards.

9. Other birds feeding on sorghum were ruddy ground doves, blue-black grassquits, ruddy-breasted seedeaters, and white-collared seedeaters (Sporaphila torqueola). Grassquits were abundant in sorghum fields. Some individuals of a flock of white-collared seedeaters netted one evening had sorghum in their mouths.

Conclusions and Recommendations

1. It will be very difficult to use chemical agents effectively to protect grain sorghum from parakeets. The parakeet's habit of "mealing the kernels" and discarding the outer seed coat will make it necessary to use very high levels of chemicals in order for them to ingest the desired amount of the agent. In very limited field tests where sorghum heads were sprayed with 4-AP in an adhesive, it was found that the frequency of rains in June in Nicaragua (three or four rains daily) did not allow the adhesive (methocel) to set up properly. Inasmuch as few sorghum fields mature when rains are this frequent, this will be a secondary problem.

2. It was not difficult to get parakeets to feed on very small treated plots. Tethering captive birds several yards from treated plots was successful in attracting others and obtaining initial feeding.

3. Distress calls will have to be reinforced with "cherry bombs" or "cracker shells" to keep parakeets out of fields. Distress calls and three exploders were not enough to prevent 700 parakeets from feeding in a 7-hectare sorghum field. No reliable firecrackers were available in Leon.

4. A maximum-effort patrol will be necessary to keep fields clear, as parakeets are very brazen and a feeding flock allows an individual (at times) to approach within 25 yards. It will probably require 2-4 days to change food sources for the parakeets attacking a particular field, for it appears that if they obtain a meal at a field they will return again the following day. For the present, use of hand-thrown cherry bombs, exploding shells, and a large labor patrol (1 man/3 hectares) for this 2-4 day period should be the cheapest and most effective method of protection.

Dove Damage to Soybeans

Eared doves are a locally serious problem in the production of soybeans in Columbia as they eat the cotyledons of emerging seedlings usually destroying the plant. The crops of 14 doves shot in a soybean planting in the Cauca Valley contained an average of 62 cotyledons per bird (Thompson and Agudelo, 1969).

They conducted tests on small plots with a DRC-736-Rhoplex AC-33 formulation supplied by this Center, coating soybean seeds with a 0.5% concentration by weight of DRC-736.

"Seven days after plots were planted with treated and untreated seed, cotyledon loss on untreated plants was 100% whereas the loss of cotyledons from treated seed was about 26%."

The effectiveness of DRC-736 should be even more pronounced in large-scale field tests. Since several partially immobilized doves were noted in an earlier test, a 0.25% level of DRC-736 is recommended for future field trials. Translocation studies of DRC-736 in soybean plants will also need to be conducted to determine possible residues.

III. Cage Tests of Damage Control Agents

Selected damage control agents--fright-producing, immobilizing, and toxic agents--were tested on problem species (or closely related species of Latin America) both at the Denver Center and at locations in Latin America where field studies were being conducted. The chemicals were either intubed in propylene glycol solutions or force-fed on cereal baits, most frequently grain sorghum.

Laboratory Data

In Denver, three toxicants, three soporifics, and a fright-producing agent were tested on budgerigar's (Australian parakeets). These compounds were selected from those found most effective on U.S. species. Data obtained are shown in the following table:

DRC #	No. birds tested	No. levels tested	Oral		Safety factor (LD_{50}/TI_{50})
			TI_{50}	LD_{50}	
Toxicants					
1339	8	4	--	242 mg/kg	--
1347	2	1	--	>32 mg/kg*	--
3895	10	5	--	24 mg/kg	--
Soporifics					
735	8	4	1.33 mg/kg	4.21 mg/kg	3.2
736	10	5	0.75 mg/kg	1.33 mg/kg	1.8
3551	16	8	32 mg/kg	178 mg/kg	5.6
Fright-producing agents					
1327	6	4	--	4.21 mg/kg	--

*Dermal LD_{50}.

The toxicity of DRC-1339 to budgerigars is similar to that for sparrows and hawks; the toxicity of DRC-3895 is similar to that for gallinaceous species. Of the soporifics, only DRC-3551 appears to have a wide enough margin to be useful. The reaction of budgerigars to DRC-1327 is about the same as other birds tested. All the information obtained reinforces beliefs that control agents should be thoroughly investigated on the species for which it is intended before field investigations are begun.

All attempts to evaluate repellents on budgerigars failed. They hulled sunflower seeds, pearl millet, and other seeds before eating them, but refused to eat hulled sunflower seeds, hulled oats, and hulled peanuts. They also refused hull-less food such as milo, cracked corn, rape seed, rice, and barley.

Although parakeets and parrotlets usually hull or crack the seeds upon which they feed in the wild, it was hoped that a seed could be found that would be acceptable for obtaining comparative laboratory data for several new and very active repellents.

Field Data

DRC-736, DRC-3551, and DRC-1327 were also tested on a number of Latin American problem species during trips into damage areas. Although only small numbers of birds were dosed, data obtained appear indicative for the species involved and are given in the following table:

DRC #	Species	Method of dosing*	No. birds tested	No. levels tested	TI_{50} mg/kg	LD_{50} mg/kg	Safety factor (LD_{50}/TI_{50})
736	Dickcissel	1	6	6	2.6-3.9	>3.9	>1.0
	Orange-fronted parakeet	1	6	3	10.8-18.0	≅18.0	1-1.7
3551	Orange-fronted parakeet	1	7	4	12.6-18.0	>50.0	>2.8
	Ruddy ground dove	1	3	3	30-96	>96	>1.0
	Ruddy ground dove	2	10	5	18-22	32-100	>1.5
1327	Ruddy-breasted seedeater	1	2	2	--	<7.2	--
	Shiny cowbird	2	4	4	--	<1.0	--
	Blue-black grassquit	1	7	5	--	9-12	--
	Orange-fronted parakeet	1	7	5	--	10.8-12.6	--
	Dickcissel	1	14	7	--	≅10	--
	Brown-throated parakeet	1	12	5	--	≅10	--
	Scaled dove	1	2	1	--	>4.0	--
	Ruddy ground dove	1	2	2	--	20-32	--

*1--Intubed using propylene glycol carrier.
2--Force-fed grain sorghum seeds containing chemical.

Most species of birds tested with the frightening agent, DRC-1327, appear to be very susceptible to this agent. Distress vocalizations were also remarkably similar to those of similar families of these species in the U.S. Shiny cowbirds were affected at lower levels of DRC-1327 than any other icterid tested to date. Levels as low as 1 mg/kg (in a propylene glycol solution) resulted in substantial displays of distress by shiny cowbirds. Orange-fronted parakeets dosed at about 20 mg/kg gave periodic distress cries for 4 hours before dying. Some individuals were able to fly between periods of distress, but all birds dosed with more than 13 mg/kg died. DRC-1327 produced only weak distress cries in dosed seedeaters and grassquits. DRC-3551, as in laboratory studies, appeared to be a more effective and safer soporific than DRC-736.

IV. Crop Residue Determinations for Damage Control Agents

A considerable effort has been expended by this Center in developing microanalytical and plant translocation methodology for DRC-1327 in corn. Much of the information learned for this promising bird damage control agent will also be applicable to the sorghum and rice problems in Latin America.

Among the findings were:

1. DRC-1327 is not phytotoxic to growing corn at 100 ppm and at lower levels may stimulate growth.

2. DRC-1327 was translocated into corn tissue, but most of the compound remained in the roots and lower stem. No evidence of DRC-1327 was found in the grain. Translocation is also slowed considerably as the plant matures.

3. DRC-1327 is tightly bound to soil particles, and only small amounts can be absorbed by plant tissue.

4. DRC-1327 is metabolized in soils and plants either to volatile pyridine or carbon dioxide.

This phase of development becomes more important daily as scientists throughout the world discover more and more harmful effects from pesticides thought to be safe when first introduced in agriculture.

Literature Cited

Cottam, C., and J.B. Trefethen (Ed.). 1968. Whitewings. D. Van Nostrand Co., Inc. 348 p.

De Grazio, J.W. 1964. Methods of controlling blackbird damage to field corn in South Dakota, p. 43-49. In Proc. 2nd Vert. Pest Control Conf., Anaheim, Calif. (Calif. Vert. Pest Tech. Comm.).

Ffrench, R.P. 1967. The dickcissel on its wintering grounds in Trinidad, p. 123-139. In The living bird (6th Ann. Cornell Lab. Ornith.).

Rohl, E. 1959. El Arrocero, p. 358. In Fauna descriptiva de Venezuela (vertebrados), Nueva Grafica S.E., Andres Mellado 18, Madrid.

Skutch, A.F. 1960. Life histories of Central American birds, II, Cooper Ornith. Soc., Pacific Coast Avifauna No. 34. 593 p.

Slud, P. 1964. The birds of Costa Rica, distribution and ecology. Bull. Amer. Mus. Nat. History, vol. 128. 430 p.

Thompson, R.L., and F. Agudelo. 1969. Crop production program semester B, 1969: Sub-project: bird control. 8 p. (Typed report, CIAT, Cali, Colombia)

West, R.R., R.B. Brunton, and D.J. Cunningham. 1969. Repelling pheasants from sprouting corn with a carbamate insecticide. J. Wildl. Manage. 33(1):216-219.

West, R.R., and J.H. Dunks. 1969. Repelling boat-tailed grackles from sprouting corn with a carbamate compound. Texas J. Sci. 21(2): 231-233.

Woronecki, P.P., J.L. Guarino, and J.W. De Grazio. 1967. Blackbird damage control with chemical frightening agents, p. 54-56. In Proc. 3rd Vert. Pest Control Conf., San Francisco, Calif. (Calif. Vert. Pest Tech. Comm.).

Young, W.R., and D.C. Zevallos. 1960. Studies with chemical seed treatments as bird repellents for the protection of germinating maize in the Mexican tropics. FAO Plant Protection Bull. 8(4): 37-42.