

EVALUATION OF CERTAIN CHEMICALS AS  
BIRD REPELLENTS, AND THE REACTION  
OF BIRDS TO THESE REPELLENTS

By

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## INTRODUCTION

### The Physiological and Morphological Basis of Chemical Repellency

Throughout historical times there has been contact between man and bird. Much of this contact has been beneficial and pleasant as the bird has furnished food, adornments and sport for man, but there has also been an element of conflict when the bird has destroyed or soiled something belonging to man. This paper deals with one phase of this element of conflict -- that of trying to repel the bird from a particular area or thing.

It was, at one time, believed that the bird had very little, if any, sense of taste or smell. There is considerable variation in the development of the olfactory bulbs in birds, the bulbs being smaller, relatively, in passerines than in ducks. There appears to be no direct relationship between bulb size and olfactory power. Some birds have only one bulb (House Sparrow) whereas others have two (crow). The debate over the olfactory power of birds has continued for a long period of time. Hamrum (1953) carried out several simple experiments and concluded that the Bobwhite possess an olfactory sense and that olfactory stimuli probably influence its choice of food. "Thus it is seen that data are

too fragmentary and contradictory to warrant positive statements regarding the importance of the sense of smell in birds." (Van Tyne and Berger, 1959). Based on morphological evidence, one may assume that some birds have a sense of smell, but research indicates this sense is probably poorly developed.

The evidence that birds have a sense of taste is almost as controversial as that for the sense of smell. There are far fewer taste nerve fibers in birds than in mammals. Most birds are said to have only 40-60 taste buds. Some parrots, however, may have about 400, whereas rabbits have 17,000 (Van Tyne and Berger, 1959). The taste buds of birds are found chiefly on the pharynx and palate.

Taste in birds has not been studied extensively. Bobwhites in Hamrum's (1953) study appeared to have some sense of taste. Kare, Black and Allison (1959) found that the chicken has a fairly keen sense of taste, but very different from that of man. The bird rejects man's well-liked honey and strawberry flavors but prefers butter flavored water above most other flavors tested.

Realizing that birds can at least detect different flavors, researchers are trying to develop taste or space repellents to replace the more or less unsuccessful deterrents such as scarecrows, carbide exploders, rope fire-crackers, shotguns, etc.

This thesis considers only taste or space repellents or deterrents and not those having sticky or tacky character-



istics. Hockenyos (1958) presents a very good discussion of sticky repellents and deterrents.

### Need for Bird Repellent Research

Little research has been done in the field of bird repellents, but evidence of bird damage points up the need for such research.

It is generally known that some birds create problems in localized areas throughout the world by roosting or feeding in certain areas. Letters received from people concerned with bird problems usually follow this theme -- "We are having local problems with birds roosting ..... and feeding ... .." "Is there a repellent against birds on the market?" "We would like information on ridding buildings of birds...."

Many authors have reported extensive damage by birds.

In 1904 Beal estimated the annual loss of rice to bobolinks to be in excess of \$2,000,000 (Beal, 1904).

During the 1920s, starlings, red-winged blackbirds, grackles, and cowbirds destroyed field corn, sweet corn, and grapes (Kalmbach, 1928).

Thomas (1954) reported that starlings were damaging grapes in one area in Australia to the amount of £10,000 per annum.

Arkansas rice growers lost up to \$1,400,000 in rice each year to blackbirds (Neff and Meanley, 1957).

Gilfillon (1958) points out that at least 1,000,000 blackbirds in four counties in Ohio were damaging crops.

In Africa in 1958, a 3,000 acre field of grain sorghum was consumed within one week by an African bird similar to our House Sparrow [Passer domesticus (Linnaeus)] (Hugh Doggett, personal communication).

Locally, similar problems with birds are present. Professor Frank Davies, Oklahoma State University Agronomist, has stated that there is almost a 100 per cent yearly loss to birds of unprotected grain sorghum plots at the University Farm and a 0 - 50 per cent yearly loss at the Perkins Farm. This is verified by observations in the area.

During the winter of 1959, Steele (1959) reported that blackbirds stripped 17 acres of maize during a 5-day period on the Canton Lake Public Hunting Grounds near Canton, Oklahoma.

Table VII shows the number of birds observed by this writer feeding in standing grain plots while making various visits to the plots. Figure 4 indicates the high visitation rate of birds to feed at a given pan plot.

Bird damage to stored grain is very high especially at elevators and feed mills.

Roosting of large flocks of birds in trees and on buildings in certain areas is highly undesirable.

Starlings (Sturnus vulgaris Linnaeus) and House Sparrows are utilizing most of the few remaining nesting sites of more desirable native species.

If control of certain species, such as House Sparrows, Starlings and several species of the family Icteridae, is not

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found, there may be pressure brought to bear to eliminate these species.

### Factors to Consider in Studying Repellents

Due to many variables apparent in field tests with an animal as mobile as a bird, it seems fitting to present some of the factors to be considered in a study of this kind.

Neff and Meanley (1956) state that the optimum requirements for a repellent are severe and may be listed as follows:

1. The substance must actually repel birds.
2. It must constitute no hazard to wildlife.
3. It must be safe for use by man both in application and as a residue.
4. It must not injure the seed or plant to which it is applied.
5. It must not be detrimental to the soil.
6. It must not adversely affect the milling or handling of the crop, or its use for animal or human food.
7. It must withstand strong sunlight, rainfall, and other climatic conditions for a reasonable length of time.
8. Cost must be reasonable, and application must be by means normally available in the average community.

There are other factors that are not brought out in the Neff and Meanley requirement list that must also be

considered when working with repellents. Following are some that are discussed in this paper:

1. Concentration of the spray.
2. Solvents, adhesives and emulsions that are suitable for each chemical tested.
3. Rate of application in pan and field tests.
4. Means of preliminary testing to eliminate chemicals before field testing.
5. Means of measuring repellency.
6. Classification of the chemical as a space or taste repellent.

Problems related to these factors and to other phases of the study will be discussed later.

#### Chemical Bird Repellents and Deterrents of the Past

Neff and Meanley (1956) gave such a good account of the past history of bird repellents that it is felt best to quote, in part, their work rather than write another resumé.

The idea of applying to the seed at planting time some substance distasteful to the birds dates far back in agricultural history. Probably farmers carried out many experiments that were never recorded. Experimental work has, however, been carried out by many workers.

Most of the published reports on experimental work with bird repellents refer to the treatment of seeds; an occasional project dealt with the use of repellents on vegetative growth, or on ripening crops. Generally speaking, studies of the use of bird repellents have been intermittent, without continuity, directed at the solving of a specific local problem.

Published reports of this nature are scattered through the agricultural biological and chemical literature of the past 150 years.....

The majority of past studies of bird repellents have been short-lived and narrow in objective, aimed at solving only a single local problem. Few have had sufficiently long duration or breadth of planning to permit more than local or temporary conclusions.....

Most of the reported studies, until very recently, were aimed at combating crows, pheasants, grackles or red-winged blackbirds, active predators on freshly planted grain, pine and other seeds.....

A summary of bird repellent studies is given in Table

I. One must remember, in analyzing the data in this table, that the chemicals were tested under varying conditions and on several kinds of seed and plants given to many species of birds.

TABLE I

SUMMARIZED RESULTS OF EXPERIMENTS  
ON BIRD REPELLENTS \*

Author	Chemical	Effectiveness As A Repellent		
		Unknown	Effective	Not Effective
Anonymous (1845)	saltpeter and copperas	x		
Anonymous (1877)	lime and gypsum	x		
Anonymous (1881)	red lead		x	
Cieslar (1886)	red lead	x		
	carbolic acid	x		
	petroleum	x		
Barrows (1889)	London purple		x	
	Paris green		x	
Barrows and Schwarz (1895)	coal tars		x	
Beal (1900)	coal tars			x
Pearson (1913)	red lead			x
Damon (1933)	engine oil and red lead		x	
Piper and Neff (1930-1941)	white of starch		x	
	black of zinc phosphide		x	
	white wash		x	
	ethyl mercuric phosphate			x
	hydroxymercuri- chlorophenol		x	
	gum turpentine			x

TABLE I (Continued)

Author	Chemical	Effectiveness As A Repellent		
		Unknown	Effective	Not Effective
Piper and Neff (1930-1941)	kerosene			x
	PESTEX (commercial repellent)			x
	COCK ROBIN (commercial repellent)			x
	quinine			x
	alum			x
	nicotine sulphate-soap solution		x	
Thiem and Sy (1941)	antimony		x	
	game-browsing tars		x	
	naphthol-yellow-S		x	
	anthracene		x	
	phenothiazine		x	
	tetramethyl thiuram disulphide		x	
	calcium nitrate		x	
Kalmbach (1943)	Brilliant Green		x	
	Brilliant Yellow			x
Fowle (1944)	solution of nicotine sulphate		x	
	naphthalene flakes		x	
Welch (1946)	Monastral Green Pigment		x	
Butterfield (1947)	sulphur			x

TABLE I (Continued)

Author	Chemical	Effectiveness As A Repellent		
		Unknown	Effective	Not Effective
Butterfield (1947)	nicotine dust			x
	Bordeaux dust			x
	cryolite			x
Bytenski-Silz (1948)	anthraquinone		x	
	benzene hexa- chloride		x	
Giban (1948)	naphthalene		x	
	dinitronaphthalene		x	
	dinitrophenol			x
	trinitrophenol			x
	dinitrocresol			x
	mercaptobenzothiazole			x
	aloes			x
	sulphur			x
	iron sulphate			x
	red ochre			x
	anthraquinone			x
	tar derivatives			x
Dambach and Leedy (1948, 1949)	Brilliant Green dye		x	
	terpene mercaptan			x
	lead oxide			x
	iron salt of nitro- betanaphthol			x
	phthalocyanide blue dye			x



TABLE I (Continued)

Author	Chemical	Effectiveness As A Repellent		
		Unknown	Effective	Not Effective
Dambach and Leedy (1948, 1949)	paratoner red dye			x
	ground naphthalene			x
	commercial coal tar		x	
	commercial kerosene			x
	phenol soap			x
Brane-Pederson (1954)	MORKIT (commercial repellent)		x	
Mann and Derr (1955)	MORKIT		x	
	anthraquinone		x	
	quinizarine		x	

\*This table is a summary of brief abstracts from text of article by Neff and Meanly (1956). Names have been written just as published and do not necessarily conform to present day spelling.

## GENERAL METHODS AND PROCEDURES

### Problems Anticipated

In setting up methods to be used and procedures to be followed, it was necessary to anticipate certain problems to be encountered in a study of this type. In working with living organisms in their native habitats many variables had to be considered, and few controls could be employed. One can note that when animals, plants and synthetic chemicals were used simultaneously in these studies the variables were multiplied. Some of the anticipated problems included:

1. Method of treating grain for pan and field tests.
2. Percentage concentration of chemical to use for each test.
3. Method of measuring repellency in pan and field tests.
4. Design of a control, and means to measure untreated grain produced in or eaten from control.
5. Motility of birds and its effect upon tests.
6. Estimation of numbers of birds feeding in each study plot.
7. Phytotoxicity of chemicals.
8. Toxicity of chemicals to birds, man and other animals.

9. Reaction of the birds to plots and to treated grain.
10. Size of pan and field plots.
11. Location of plots.
12. Weather effects upon stability and effectiveness of chemicals.

#### Field Tests vs. Cage Tests

After evaluating the relative merits of testing the chemicals in the laboratory with caged birds or on wild birds in the field, it was decided to field test the candidate repellents. Although more variables might be presented in field testing, this method would save time in that the repellent would be more nearly ready for practical use if it were found to be effective. Repellents tested on caged birds would have to be field tested if found effective in the laboratory.

Cage tests present many factors not normally found in field tests:

1. The effects of confining the bird to a cage.
2. The bird has no normal feeding pattern.
3. The bird loses its social contact with others of its kind.
4. The choice of feeding areas and of foods is absent.
5. The bird must choose between the candidate repellent and a known repellent as no other food is available.

Another factor serving to favor the field tests over the cage tests was that prior to these tests most of the chemicals used had been tested with Coturnix Quail Coturnix coturnix (Linnaeus) in the Phillips Petroleum Company laboratory, Bartlesville, Oklahoma. Only those showing repellency in the Phillips tests were used in these experiments.

As very little research has been done with chemical materials as bird repellents on a large scale and over a long period of time, many of the ideas and techniques presented herein are new in this field of research and have been developed by experimental means or by adaptations from other fields of research.

#### Methods and Procedures for Over-all Problem

Because different experimental methods and procedures had to be employed for each type of study within this problem, this paper presents a section for each study: Pan Test Studies, Standing Grain Studies and Marked Bird Studies.

The Pan Test was designed as a preliminary test for all candidate repellents. A measured amount of grain sorghum (Sorghum vulgare Pers.) was treated with a known concentration of the chemical to be tested. The treated grain was measured into receptacles which were placed in the selected test plots. Birds were attracted to the plot by prebaiting prior to each test. Observations of the birds'

reaction to the plot and to the treated grain were made. After a testing period of seven days, the grain remaining in the pan was again measured to check the amount consumed. This consumption was compared to the consumption of grain in the control. Grain consumption and the bird's reactions to the plot indicated the repellency of the chemical.

The chemicals showing a promising degree of repellency were tested in the Standing Grain plots. A known concentration of the chemicals was sprayed on the heads of grain sorghum standing in the field. A given number of the heads were bagged before spraying to serve as a production index. Part of each field was used as a control and was not sprayed, but, here again, a given number of the heads were bagged. Observations of bird numbers, approaches, feeding patterns, reactions to plot and chemical, and feeding times were noted. Bird counts were made by the direct count or the relative abundance count methods (Wing, 1956). Bagged and unbagged heads from treated and non-treated areas were collected and weighed. A comparison of the consumption of treated and non-treated grain, and the birds' reactions to the plot, indicated the repellency of the chemical.

The marked bird study was designed to better define the range of birds using a given plot. Trapped House Sparrows and Brown-headed Cowbirds Molothrus ater (Boddaert) were banded and marked with a plastic necktie. Numerous observations made at various distances from the traps helped to delineate the range of the birds under study.

## Sources of Materials

Chemicals tested in this experimental work were furnished without cost by the following companies:

S. B. Penick and Company, New York

B-5-2T

B-5-2,2GT

B-5-2TV

B-27

Niagara Chemical Division, Middleport, New York

Bitters

Kolo 500

MR 493

American Cyanamid Company, New York

Anthraquinone\*

Bonide Chemical Company, Utica, New York

Cro-tox\*

Rohm and Haas Company, Philadelphia, Pennsylvania

Rhoplex\* AC-33

California Spray-Chemical Company, Richmond, California

Ortho\* ML100

Winthrop Laboratories, New York

Anthraquinone\*

Shawinigan Products Co., New York

Alvar\*

I. E. duPont de Nemours and Company, Wilmington, Delaware

Arasan\* 42-S

Flavor Corporation of America, Chicago, Illinois

Sucro-flavor\*

Phillips Petroleum Company, Bartlesville, Oklahoma

All the coded chemicals except those listed above.

\*Trade names

At the present time, the author is not at liberty to divulge the names of all the coded chemicals. A partial list is given in the Appendix. A complete list is to be published later.

All the work herein reported was done on Oklahoma State University property. With the cooperation of the faculty and staff of various departments (see acknowledgements), plots were located in livestock feed lots, pastures and at the Agronomy Farm.

## PAN TEST STUDIES

### Specific Methods and Procedures

Plots designed for preliminary testing of candidate bird repellents were called pan test plots. These were originally set up by placing nonperforated metal pans in a pattern as shown in Figure 2. Each pan was filled with a measured amount of treated grain, a different chemical in each pan. As the pans soon filled with water, causing the grain to sour or preventing the birds from feeding on the grain, a different test container was sought. Plastic sink strainers were found to be ideal (Figure 1). As simulated field conditions were being sought in these studies, the strainers permitted maximum water run-off during rainstorms, and maximum sunlight and oxidation. The strainers were weatherproof and easy to clean. Modification of the original plot pattern were made by placing two pans at each pan location, each pair of pans containing the same chemical but in different percentages; or by using four rows of 4-5 pans in each row with the same chemical and same concentration throughout the plot. No controls were used in these latter tests. The amount of untreated grain consumed during the last 24 hours of the prebaiting period was used as a control figure. Prebaiting for a test was usually continued until all the



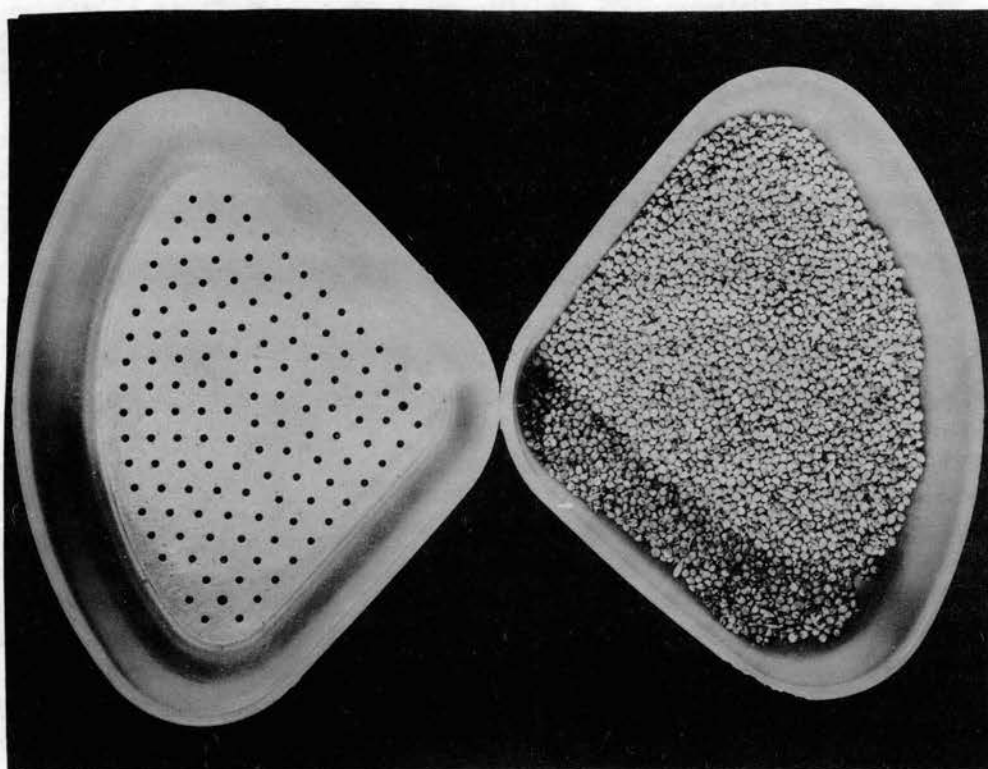


Figure 1. Containers found to be most satisfactory for pan tests.



Figure 2. Layout of preliminary test plot showing coded chemicals and control arrangement. (Griffin and Baumgartner, 1959).

untreated grain placed in pans was consumed in one day. At this time, a test using treated grain was started.

The pan plots were named to designate location, e.g., Horse Barn plot, Sheep Barn plot, Brick Pile plot, Weather Station plot, etc.

After many selected sites for pan test plots had failed, for no apparent reason, to attract birds during the prebaiting period, it was later found that the success of a plot depends to some extent, on the following factors:

1. Concentration of birds - The plot should be located at a point very near a high concentration of feeding birds.
2. Access to the plot - It should be accessible by a motor vehicle, if possible, as grain and equipment must be carried there periodically. Observations can be made from the auto during inclement weather if plot is so located.
3. Ease of observation - The plot, pans and birds must be easily observable, preferably from a motor vehicle.
4. Freedom from disturbance - The plot must be located away from heavy traffic by humans. One of the plots was disturbed three times and equipment stolen by pranksters.
5. Location - Plots located too near buildings attract Norway Rats Rattus norvegicus (Berkenhout); wooded

areas, Wood Rats Neotoma floridana (Ord)<sup>7</sup>; and weeds and tall grasses, Cotton Rats (Sigmodon hispidus Say and Ord).

6. Physical nature - The site should be smooth, well drained, and open so that the pans are visible to birds and to the observer. A mowed grass sod proved most desirable.
7. Wildlife competition - To help prevent competition from other wildlife such as Cotton Rats and rabbits, a heavy cover of grass and weeds on the plot must be avoided by regular clipping.
8. Fencing - Fencing is usually necessary to keep intruders from destroying a plot. Livestock destroyed several of the tests at one time or another.

#### Testing Techniques

Forty-five chemicals were tested as candidate bird repellents by the pan test method (Tables II, III, IV). Companies furnishing these chemicals are listed on pages 16 and 17.

The chemical to be tested was weighed, if a solid, and this weight figured as a per cent of the weight of the grain (w/w) to be treated. If the chemical was a liquid, the volume was figured as a per cent of the weight of the grain (v/w) to be treated. The chemical to be tested was dissolved in 25-50 cc. of acetone or water. If a "sticker" were to be used, it was added to the above solution. This solution was

poured over a measured amount of white Kaffir or yellow Milo seed in a glass jar. The grain was thoroughly tumbled until the grain was covered with the solution. The grain was then immediately taken to the plot and placed in the pans.

The test was continued for seven days. If all of the treated grain was consumed before the end of the full testing period, the test was terminated, and untreated grain was placed in the pans to bait the birds to the plot before another test was begun. If the test continued for the full seven days, the grain remaining in the pans was measured and the amount was recorded. Summary sheets for each test were made and filed (Figure 3). Rainfall was recorded for each testing period and its effect on each test was noted.

The percentages of grain consumed were tabulated for each test and a rating as a repellent was assigned each chemical tested in three or more pans (Tables II, III, and IV). The candidate repellent was rated good if 0-20 per cent of the treated grain was consumed; fair, if 21-35 per cent was consumed; and poor, if 36-100 per cent was consumed.

#### Results of Pan Testing

Of the forty-five chemicals tested, 10 were rated good at 1.0 per cent and 1 at 0.25 per cent concentration. Of those rated fair, there were 6 at 1.0 per cent and 2 at 0.25 per cent. A poor rating was assigned 2 at 5.0 per cent, 13 at 1.0 per cent and 5 at 0.25 per cent.

TABLE II

CHEMICAL TREATED GRAIN SORGHUM CONSUMED  
BY BIRDS IN LARGE TEST PLOTS

Chemical	Concentra- tion in Per cent*	No. of Tests	Total No. of Pans	Per cent of grain Eaten	Rating		
					0-20% Good	21-35% Fair	36-100% Poor
978	1.0	1	20	100.0			X
1255	1.0	1	20	33.0		X	
Bitters	5.0	1	16	40.9			X
Arasan 42-S	5.0	2	36	7.6	X		
1274	0.6	1	12	4.1	X		
1489	1.0	2	21	0.5	X		
1509	1.0	2	24	2.0	X		
1281	1.0	2	28	30.0		X	
1566	1.0	1	16	0.0	X		
1070	1.0	1	16	87.5			X
1070	0.5	1	16	100.0			X
5	1.0	1	16	30.0		X	
5 <sup>1</sup>	1.0	1	16	60.1			X
Anthraqui- none	5.0	1	16	100.0			X
Crotox	1.0	1	12	0.0	X		
Acetone	0.02	1	20	100.0			X
Sucro	1.0	1	20	100.0			X
Urea	1.0	1	20	100.0			X
Urea	5.0	1	20	100.0			X

<sup>1</sup>Previous test extended for 7 days

\*w/w if a solid; v/w if a liquid

TABLE III

PER CENT OF GRAIN TREATED WITH ONE PER CENT CHEMICAL  
THAT WAS EATEN FROM PANS\*

Chemical	No. of Tests	Total No. of Pans	Percent of Grain Eaten	Rating		
				0-20% Good	21-35% Fair	36-100% Poor
1255	7	9	3.0	X		
1267	4	4	47.5			X
1256 <sup>1</sup>	1	1	100.0			
1265	3	3	23.0		X	
978	3	6	83.4			X
1273	3	3	19.0	X		
1275	3	4	5.0	X		
1266 <sup>1</sup>	2	2	22.3			
1274	3	3	11.0	X		
1058	6	7	17.8	X		
Anthraquinone	4	7	100.0			X
Kolo 500	2	3	100.0			X
Crotox <sup>1</sup>	1	2	50.0			
Alvar	2	3	100.0			X
Ortho ML 100	1	1	100.0			X
Niagara MR 493	1	1	100.0			
1383	2	4	18.8	X		
1281	2	4	73.0			X
26	2	4	93.8			X
751	2	4	29.8		X	
1217	2	4	21.3		X	
Pen. B-5-2T	2	4	75.0			X

TABLE III (Continued)

Chemical	No. of Tests	Total No. of Pans	Per cent of Grain Eaten	Rating		
				0-20% Good	21-35% Fair	36-100% Poor
Pen. B-5-2.2 GT	2	4	100.0			X
149	2	4	85.5			X
1353	3	4	31.2		X	
885	3	4	21.8		X	
749	3	4	36.2			X
493	3	4	26.7		X	
5 <sup>1</sup>	2	2	50.0			
888	3	4	43.2			X
9	2	3	5.0	X		
1215	3	4	22.5		X	
1323	2	3	5.0	X		
790 <sup>1</sup>	1	1	0.0			
564 <sup>1</sup>	1	1	0.0			

<sup>1</sup>Insufficient tests to rate

\*w/w if a solid; v/w if a liquid.

TABLE IV  
PER CENT OF GRAIN TREATED WITH LESS THAN ONE PER CENT  
CHEMICAL THAT WAS EATEN FROM PANS\*

Chemical	Per cent	No. of Tests	Total No. of Pans	Per cent of Grain Eaten	Rating		
					0-20% Good	21-35% Fair	36-100% Poor
Anthraqui- none	0.5	4	7	100.0			X
5 <sup>1</sup>	0.5	1	2	10.0			
564 <sup>1</sup>	0.5	1	2	17.5			
790 <sup>1</sup>	0.75	1	2	17.5			
1255	0.25	6	6	20.9		X	
1267	0.25	3	3	75.0			X
1256	0.25	3	3	90.0			X
1275	0.25	5	6	13.9	X		
1266	0.25	5	5	39.0			X
1274	0.25	5	5	33.4		X	
1273	0.25	5	5	37.2			X
1058	0.25	4	4	44.3			X
1265 <sup>1</sup>	0.25	2	2	100.0			

<sup>1</sup>Insufficient tests to rate

\*w/w if a solid; v/w if a liquid



## INDIVIDUAL TEST PLOT SUMMARY SHEET

Test No.: 15		Location: Western St. Plot	
Dates: August 3 - 9, 1958		Duration: 7 days	Rainfall: 0.89
Prebaiting July 23 - August 3, 1958 = 11 days			
Code	%	2 cups Grain/pan	Comments
Thiram	5	20 pans Bal. in pans 1.75, 1.75, 1.5,	Thiram in pan tests appeared
(Arasan 42-S)		1.5, 1.5, 1.75,	to be a very good repellent as
		2., 1.75, 1.75,	only 13.6% was eaten in 7 test
		1.75, 1.9, 1.75,	days.
		1.9, 1.5, 1.9,	Only 21 birds were seen in
		1.33, 1.75, 1.75,	plot during observations over
		1.9, 1.9	testing period of 7 days. These
		Total balance in	birds were seen the first 4 days
		pans 34.58 cups =	of test, 15 of them the first day.
		86.4%, therefore	No birds were seen to feed after
		13.6% was eaten.	the second day. No rats were
			seen in the plot during test.
			In contrast, during the 11
			day prebaiting period preceding
			this test, 312 birds and 10 cotton
			rats were seen feeding in the plot.
			The pans were refilled 5 times
			and were empty at the time test
			was set up.

Figure 3. Example of an individual test plot summary sheet.

Other data that are given by the rating tables (Tables II, III, and IV) are: per cent concentration of chemical, number of tests for each chemical, total number of pans in which each chemical was tested and the percentage of the treated grain that was eaten.

#### Observations of Birds in Relation to Pan Tests

It was generally felt that although the amount of treated grain consumed should indicate its repellency, more reliable evidence would be obtained if observations of the birds' reactions to the repellent were recorded. The following incidents indicate the reasoning behind this statement and the relationship between the two methods of measuring repellency:

All the treated grain in pan test #7 was consumed in two days. Test #8 was a repetition of #7, but even after the full testing period of seven days, all the pans were not empty. Why would grain treated in the same manner, placed in the same pans, in the same plot and with the same population of birds not be consumed? Observation of the birds' behavior gave a probable answer. Straw bedding from cattle stalls had been spread along a large ditch just outside the plot to prevent erosion. This was done following test #7, but prior to test #8. During the second test period, the birds moved from the test plot into this straw to feed.

Phillips' candidate repellent #1070 showed no repellency as indicated by grain consumption and also by observed feeding of birds. Observations during the testing of this chem-

ical showed numerous sick and dead House Sparrows in the plot area soon after the test was started. A search of the surrounding area yielded thirty dead and several sick birds. Eighteen of these were autopsied to check food eaten. White Kaffir seed (like that used in the test) was found in eleven of the birds. No dead birds were found on the second day although the birds finished eating the treated seed. A comparable test was conducted a few days later with similar results. Thirty dead birds were again found. Autopsy of these revealed grain in ten. Again, no dead birds were found on the second day. Had grain consumption alone been used as a criterion for repellency, the toxicity of this chemical would not have been found. Neither would it have been known that this chemical lost its toxicity within a period of twenty-four hours.

Another reason for observations was to find what food the birds turned to if the treated grain was repellent to them. A definite answer cannot be given to this, but in many instances, the birds went back to their former source of food such as feed troughs, cattle droppings, and scattered grain on the ground.

The reaction of birds to treated grain was also noted by observations. In some instances, birds flocked into a plot as they had while feeding on untreated grain during the prebaiting period. After trying one or two grains from a pan, many flew to another pan, and then another, etc., sampling a grain or two from each. As these birds left the

plot, others replaced them going through the same or similar patterns of feeding. Many times, birds were seen to approach a pan of treated grain, circle it three or four times and move to another, reacting the same way at each pan.

The number of birds using a plot before and during a test was indicative of the repellency of a chemical. This was borne out by observations. Pan test #15, using 5.0 percent Thiram (Arasan 42-S), showed this very well. During observations of the plot at various times during the 7-day testing period, only 21 birds were noted in the plot; 15 the first day and none after the fourth day. In contrast, during the 11-day prebaiting period, 312 birds were observed feeding in the plot.

Numerous observations helped to disprove the general belief that birds do most of their feeding during the very early morning and very late afternoon. Figure 4 shows the average feeding population of House Sparrows during 30-minute intervals as noted by continuous observations during the daylight hours. Counts were made by the direct count method (Wing, 1956). Note the heavy feeding (200 birds every hour) all day with a very large number of birds between 12:00 Noon and 2:00 P. M., and from 4:30 P. M. to 6:30 P. M.

During the migration period, Brown-headed Cowbirds tended to use the plots more in the evening as they came in to roost than during the rest of the day. However, the maximum number of Cowbirds seen in a plot was at 1:30 P. M.

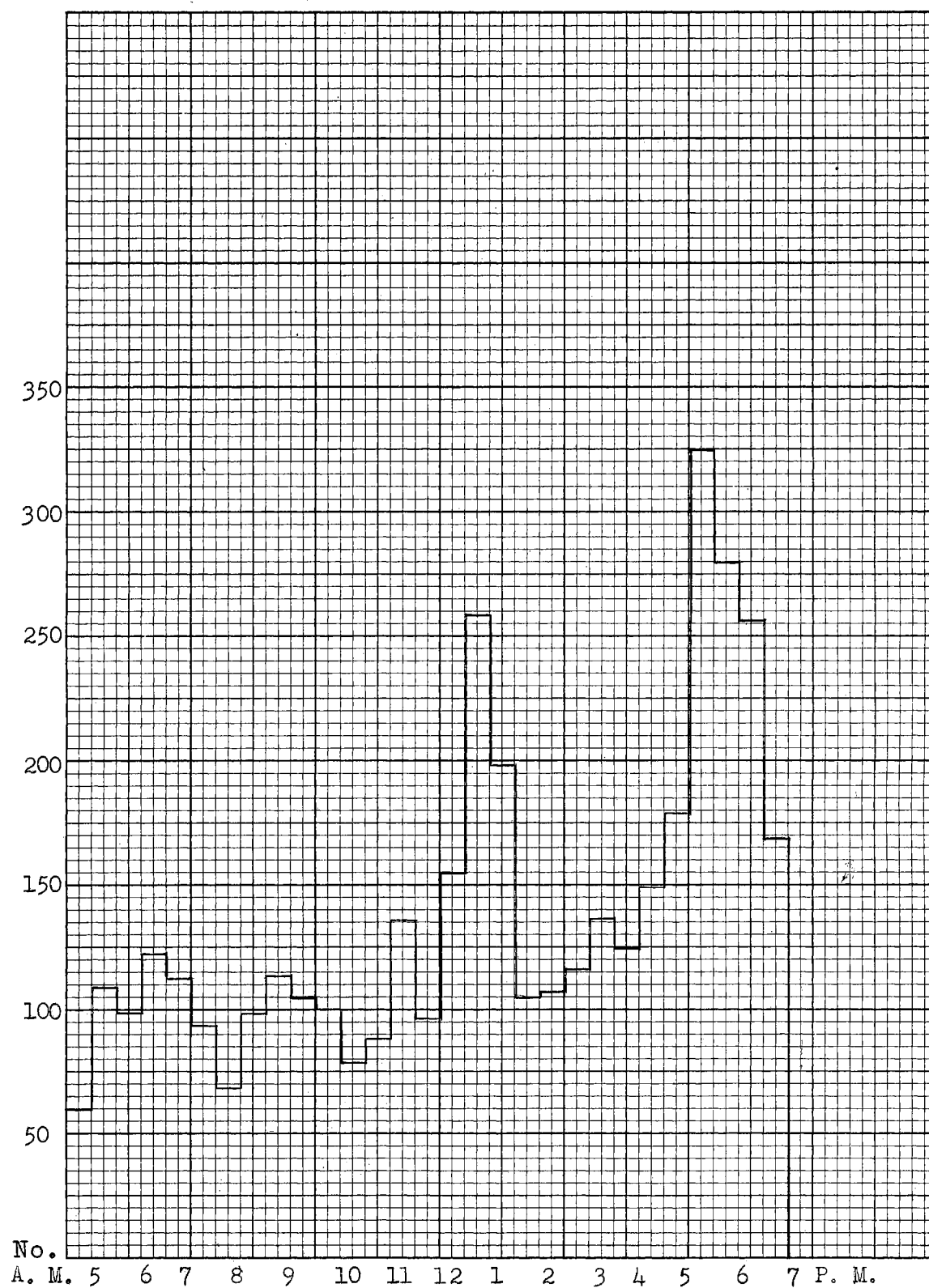


Figure 4. Mean number of birds feeding during 30 minute intervals in the Horse Barn plot as noted by continuous observations (3 days)

one day when 1200 visited the plot. Not enough observations were made to indicate the feeding pattern of cowbirds as they left their roosts in the early morning.

## STANDING GRAIN PLOT STUDIES

### Specific Methods and Procedures

#### Plot Size and Layout

Repellents proving effective in the pan tests were field tested by spraying on standing grain sorghums. Here again, new techniques had to be developed. No standards had been set for concentration of sprays, rate of application, time of application, method of application, size of plots, location of plots, type of controls or methods of measuring repellency. Several approaches to this problem appeared to give definite and satisfactory results.

The plots were located near a large population of House Sparrows and on a travel lane for Cowbirds going to roosts (Figure 8). The size of the plots within a field varied during the course of the experiments. It was found that one quarter to one half of an acre was the most satisfactory size for a test plot. This plot size permitted optimum observation of birds and grain. It could be sprayed within a reasonable length of time, could be isolated from other plots, and was large enough to permit gathering of an adequate sample of grain heads for weighing. Plot layouts varied from many strips treated with different chemicals (Figure 5) to a whole

plot treated with one chemical (Figure 6C). Variations between these two extremes can be seen in Figure 6A, B, D, E and F.

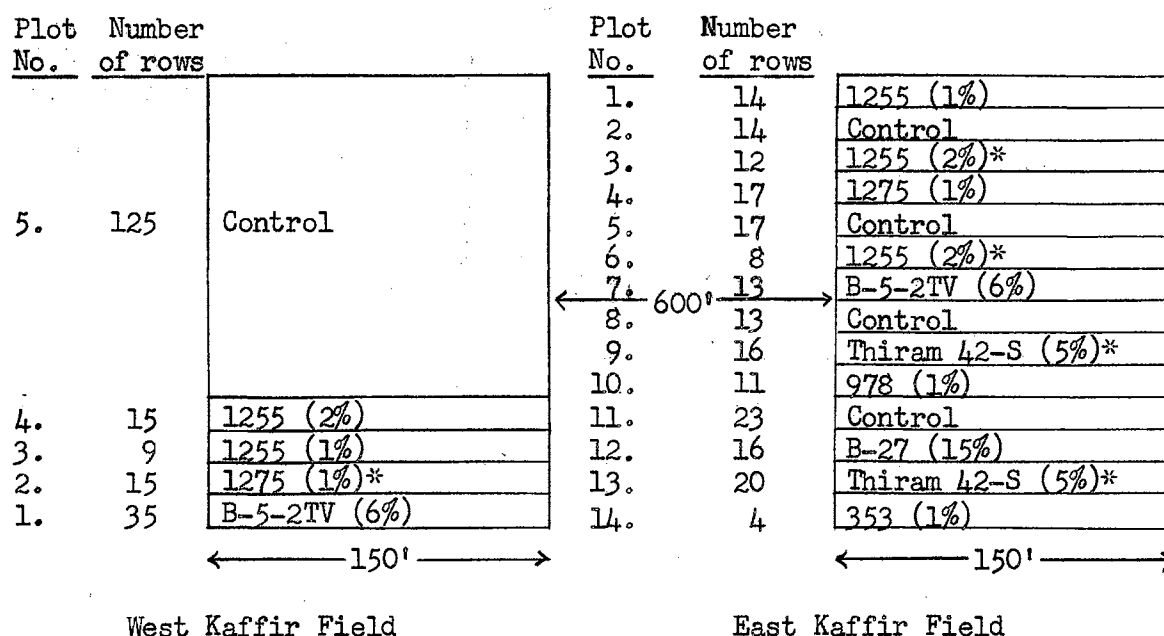
In most studies, part of a plot was designated as a control and was not sprayed. To arrive at an accurate figure of grain production from protected heads, and to have a figure to compare production rates between the treated and control areas, ten heads on each row were bagged with waterproof selfing bags. The bags had been treated with aldrin to prevent insect damage to the grain (Dahms, 1955). These were slipped over the heads and stapled. Although a new technique in bird repellent studies, this was found to be a very satisfactory method of protecting grain. It is a more economical and a less laborious method than others studied. This technique was not employed until the 1959 testing period.

#### Spraying Technique and Its Implication

Observations at the plots indicated that the birds start feeding on grain sorghum in the milk-dough stage. This period was selected as the time for the initial spraying.

Application of the spray was made by the use of portable compressed air sprayers, or of a spray cart designed and built by Dr. Lyle D. Goodhue and others at the Phillips Petroleum Company. An attempt was made to hit each head from above with spray from the portable sprayer. Some heads were wetted much more than others. Poor coverage was shown in 1958 by the addition of a fluorescent material to the spray with which the heads were treated. The heads were later examined under ultra-violet light. The spray cart produced a





\*These plots matured about 30 days after the grain was in the milk-dough stage in the other plots. At the time these plots were sprayed heavy feeding was already in progress in the other plots.

Figure 5. Diagram of field layout for spray test of standing grain sorghum during 1958.  
(Griffin and Baumgartner, 1959.)

very even mist covering all parts of the head. The "Goodhue spray cart" consisted of a two-wheeled cart with an aluminum frame covered by a canvas. Six cone jet spray nozzles were mounted to the frame so as to spray a fine mist on the heads from all directions. Pressure was maintained at 55 pounds by use of a CO<sub>2</sub> tank. This would appear to be an ideal way to spray the heads. It was the easiest and least strenuous method. Observations after spraying seem to indicate that uneven spraying, as with portable compressed air sprayers, tended to repel the birds more effectively. Apparently, some heads were thoroughly wetted and thus birds moving about, feeding from

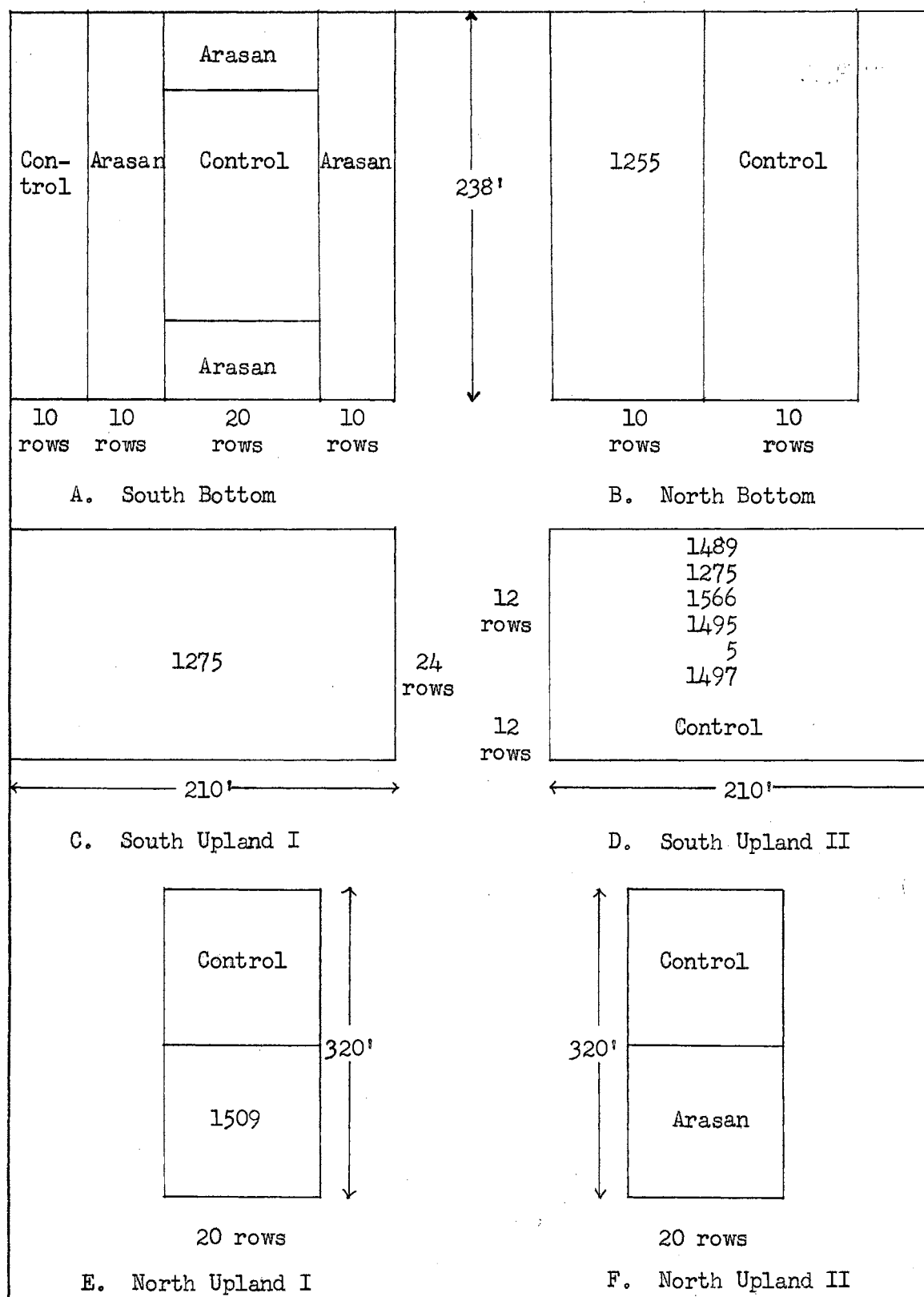


Figure 6. Plot layouts for the 1959 field test spraying of standing grain sorghums.

head to head, encountered heads with a high concentration of spray and were repelled from the plot. Plots sprayed with the cart in 1959 did not show the repellency that hand sprayed plots did in 1958.

Rate of application varied from ten gallons per acre with the cart to 20-30 gallons with the portable compressed air sprayers.

Table V lists the chemicals tested on standing grain sorghums. This table is also the source of additional information on each of the chemicals tested. Column 2 refers to the physical characteristics, liquid or powder. The per cent concentration in column 3 refers to the per cent of chemical to total volume of spray used for each specific test. The rate of application of the spray in gallons per acre is found in column 4. The carrier indicates the liquid in which the chemical was mixed to form the spray. Some sprays had a "sticker" added as indicated in column 6. The next column shows the plot in which each chemical was tested.

#### Results of Field Testing

Column 8 of Table V gives the relative effective values of the chemicals as rated by data from weighed heads and from field observations.

A possible cause of the poor repellency of the chemicals in the East Kaffir plot in 1958 might be the pattern of small treated strips interspersed with control strips. Field observations indicated that the birds had started feed-

TABLE V  
SUMMARY OF CHEMICAL TREATMENT OF STANDING GRAIN PLOTS

Chemical	Physical Characteristic	Per cent Concen- tration	Rate of Applica- tion (gal./a.)	Carrier	Sticker	Plot	Results
							XXXX Very Good XXX Good XX Fair X Poor
1255	Liquid	1	20	H <sub>2</sub> O	None	East Kaffir	X
1255	Liquid	2	20	H <sub>2</sub> O	None	East Kaffir	X
1275	Liquid	1	20	H <sub>2</sub> O	None	East Kaffir	X
1255	Liquid	2	20	H <sub>2</sub> O	None	East Kaffir	X
B-5-2TV	Liquid	6	20	H <sub>2</sub> O	None	East Kaffir	X
Arasan 42-S	Powder in suspension	5	20	H <sub>2</sub> O	None	East Kaffir	X
978	Liquid	1	20	H <sub>2</sub> O	None	East Kaffir	X
B-27	Liquid	15	20	H <sub>2</sub> O	None	East Kaffir	X
Arasan 42-S	Powder in suspension	5	20	H <sub>2</sub> O	None	East Kaffir	X

TABLE V (Continued)

Chemical	Physical Characteristic	Per cent Concen- tration	Rate of Applica- tion (gal./a.)	Carrier	Sticker	Plot	Results
							XXXX Very Good XXX Good XX Fair X Poor
353	Liquid	1	20	Oil	None	East Kaffir	X
1255	Liquid	2	20	H <sub>2</sub> O	None	West Kaffir	XXX
1255	Liquid	1	20	H <sub>2</sub> O	None	West Kaffir	XXXX
1275	Liquid	1	20	H <sub>2</sub> O	None	West Kaffir	XXXX
B-5-2TV	Liquid	6	20	H <sub>2</sub> O	None	West Kaffir	XXX
1489	Liquid	5	10	H <sub>2</sub> O	None	Sunflower	X
1489	Liquid	5	10	Soltrol 130	Butarez	South Upland	XXX
5	Powder	5	10	Acetic Acid + H <sub>2</sub> O	Butarez	South Upland	XXX
1275	Liquid	5	10	Soltrol 130	Butarez	South Upland	XXX
1495	Liquid	5	10	Soltrol 130	Butarez	South Upland	XXX

TABLE V (Continued)

Chemical	Physical Characteristic	Per cent Concen- tration	Rate of Applica- tion (gal./a.)	Carrier	Sticker	Plot	Results	
							XXXX	Very Good
							XXX	Good
							XX	Fair
							X	Poor
1497	Liquid	5	10	Soltrol 130	Butarez	South Upland	XXX	
1566	Liquid	5	10	Acetic Acid +H <sub>2</sub> O	Butarez	South Upland	XXX	
Arasan 42-S	Powder in suspension	5	20	H <sub>2</sub> O	Ortho	South Bottom	XXXX	
Arasan 42-S	Powder in suspension	5	20	H <sub>2</sub> O	Butarez	North Upland	X	
1255	Liquid	5	20	H <sub>2</sub> O	Butarez	North Bottom	XX	
1509	Liquid	1	20	H <sub>2</sub> O	Butarez	North Upland	X	
1275	Liquid	1	20	H <sub>2</sub> O	Butarez	South Upland	X	

ing on the control strips and then had shifted to the adjoining treated strips. The same chemicals when sprayed in large blocks with a large control at one side, as in the West Kaffir plot, gave good to very good results.

One might ask, why the repellents sprayed in two-row strips in the South Upland plot in 1959 proved effective? Any one or all of four reasons may have accounted for this: first, these were different and possibly better repellents than those used in 1958; second, Soltrol 130 was used as a carrier for most of these sprays whereas water had been the carrier in other tests; third, a large Cooper's Hawk Accipiter cooperi (Bonaparte) hunted the plot part of the time; and fourth, a nearby plot of grain sorghum of the variety called Ladore, although repellent in the milk-dough stage, appeared to be very palatable in the hard-dough stage.

The contradictory results obtained with Arasan 42-S in two different plots cannot be fully explained. Very heavy feeding was in progress before and at the time of spraying in the North Upland plot. Apparently, the birds had developed a strong habit of feeding on this food source and continued to do so despite the treatment of the heads. The Upland Plot was also located near suitable cover for the birds, whereas the South Bottom plot was not. For a period of time (August 1-15, 1959), up to 6000 Cowbirds and 500 House Sparrows were feeding in the South Bottom plot. Apparently, most of the Cowbirds migrated and the sparrows shifted to the two Upland plots. About the time of the

shift, a large female Cooper's Hawk was seen harassing the birds in the Bottomland plot. The birds consumed the grain in the North Upland plot and then moved to the South Upland plot. A few sparrows were seen to return to the South Bottom plot on October 4, 1959. The repellency of the Arasan in the Bottom plot compared favorably with the pan tests results (Tables II, III, IV).

In addition to observation of bird usage of the plots, and visual damage to the heads, a technique of weighing sample heads was devised. Ten heads on each row had been bagged prior to bird feeding for use as a control to obtain weights of heads not damaged by birds or insects. Since a wind storm and two floods knocked down some of the bagged heads, only those standing and free of mud or sprouted grain were gathered and weighed. Therefore, the actual numbers weighed for each plot varied. A comparable number of non-bagged heads was also gathered and weighed. The stem of each head was cut to a uniform length of one inch before weighing. All weights were converted to grams per 100 heads for ease of computation and comparison.

In Table VI is tabulated the weights of heads expressed in grams per 100 heads for each of the study plots. A total of 3080 heads were weighed -- 1540 bagged and 1540 non-bagged.

In each test, the bagged heads from the control areas were heavier than the bagged heads from the treated areas. This may be an indication that the repellent sprayed on the plants had reduced the head weight. A very marked difference



in these weights is shown for the North Upland plot where the control bagged heads weighed 7850 gms. whereas the treated bagged heads weighed 5280 gms., a difference of 2570 gms. /100 heads, a loss of 32.7 per cent in weight because of treatment. This could have been caused by the candidate repellent, #1509, a cotton defoliant, which damaged the leaves of the sorghum plants (Figure 7).

Lower production of grain in the treated areas of other plots when compared to their control areas is shown:

South Bottom plot 7410-6117 = 1293 gms., a 17.4% loss

South Upland plot 6220-5530 = 990 gms., a 15.0% loss

North Bottom plot 7860-7140 = 720 gms., a 9.1% loss

From the above information, it is apparent that the repellent caused a reduction in grain yield. It has been suggested that the chemical #1509 may have caused an increased moisture loss from the plant, thus reducing the weight of the heads.

There was no significant difference in the treated and control non-bagged head weights in either of the bottom land plots. This might indicate equal feeding in both treated and non-treated areas of the plots. This is borne out by observations, especially in the North Bottom plot. There was no apparent difference in grain consumption of the treated and control areas in the North Bottom plot -- 7.8 per cent eaten in the treated area and 9.5 per cent eaten in the control area. However, there was a significant differ-



Figure 7. Leaf damage to sorghum plants sprayed with chemical bird repellents.

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ence found in the percentages eaten in the control and treated areas of the South Bottom plot. The consumption in the control area (22.0%) was considerably higher than that for the treated area (7.3%). This statement appears to conflict with the first sentence of this paragraph. The weights of the non-bagged heads were very comparable, 5670 and 5775, but the weights of the bagged heads were strikingly different, 6117 and 7410. This indicates much heavier feeding in the control.

It must be brought to the readers' attention that the South Bottom plot was only a part of a much larger field (Figure 6A). Heads gathered from the field outside of the plot boundaries indicated heavier bird feeding than in the test plot. The mean weight of 200 heads from this field was 4487 gms./100 heads, indicating 39.3 per cent consumption. The discussion under Bird Observations may help to clarify this by explaining bird usage of the areas for feeding.

There was no marked difference in the treated and control non-bagged head weights in the North Upland plot. Almost all the grain on the non-bagged heads was eaten in this study plot. This was in evidence from feeding observations of the birds, and head examinations, and also from the difference in weights of the bagged and non-bagged heads -- 5280 to 1820 in the treated part and 7850 to 2020 in the control part. The chemical used on this plot, #1509, showed no repellency. Similar results were found for Arasan in North Upland II plot.

In the study at the South Upland plot, the chemicals seemed to show some repellency as indicated by bird observations and by head weights. Only 22.6 per cent, 1250 gms./100 heads, was eaten from the treated area. However, it must be noted that 15.0 per cent less grain was produced on the treated area than on the control area:  $6520 - 5530 = 990$  gms./100 heads lost by treatment. One must consider the economic feasibility of a treatment that saves only approximately 12.0 per cent of the grain. In all prob-

ability, the cost of treatment would offset the value of the increased yield.

#### Observations of Birds in Relation to Standing Grain Plots

Observations of bird behavior have played a large part in this study of bird repellents. As bird repellent studies, on a comprehensive scale, are relatively new, it was felt that a study of bird movements, approaches to plots, reaction to treated areas, feeding patterns and feeding ranges would be of great value in evaluating candidate repellents.

The most commonly used approaches by birds visiting the standing grain plots are shown in Figure 8. The Agronomy Farm was located on a flightline for cowbirds from rural feeding areas to the northwest to urban roosting areas east of the farm. The direction of approach of cowbirds to the farm was generally on this flightline from the northwest. This course brought the birds directly to plots 4, 5, and 6. By altering their course to the southwest, just as they entered the farm, the birds readily reached plots 1 and 2; a turn to the south three-fourths of the way across the farm brought them to plot 3.

House Sparrows, having a less extensive range, had a more direct approach to each plot. Those feeding in plots 3, 4, and 5 and to some extent 6, came from residential areas to the south and east of the farm. Those feeding in plot 6 came mostly from the Sheep Barn to the north. The sparrows using plot 1 were apparently the same population that later

fed in plots 3 and 4. Very few sparrows were seen to feed in plot 2.

The numbers of birds feeding in the various plots varied between species and from day to day. The direct count and relative abundance count methods were used to estimate the numbers of feeding birds (Wing, 1956). The sparrow population tended to be more stable over a period of time, the numbers fluctuating less and some birds being present in the area more often than in the case of the cowbirds. Cowbird numbers in the plots varied from 0 to 6000 with large numbers present for short periods of time. The sparrow numbers were more constant with populations of approximately 150 in plot 3 and 500 in plot 4. During 1958, a fairly constant population of sparrows was noted in plots 5 and 6. Table VII lists population numbers picked at random from field notes.

The map (Figure 8) also indicates the feeding pattern of birds within each plot. There was a marked difference in the feeding patterns of 1958 and of 1959. Plots 5 and 6, in 1958, revealed a definite pattern of the birds feeding first at the corners and borders of fields, then working inward. This was also true of plot 3 during 1959. In the case of plot 5, the birds ate the control strips and then spread into the borders of the treated strips. In plots 1, 2, and 4 during the 1959 tests, both the sparrows and cowbirds first alighted in the middle of the fields and fed outward. While observing wheat, oat, and barley fields in the same

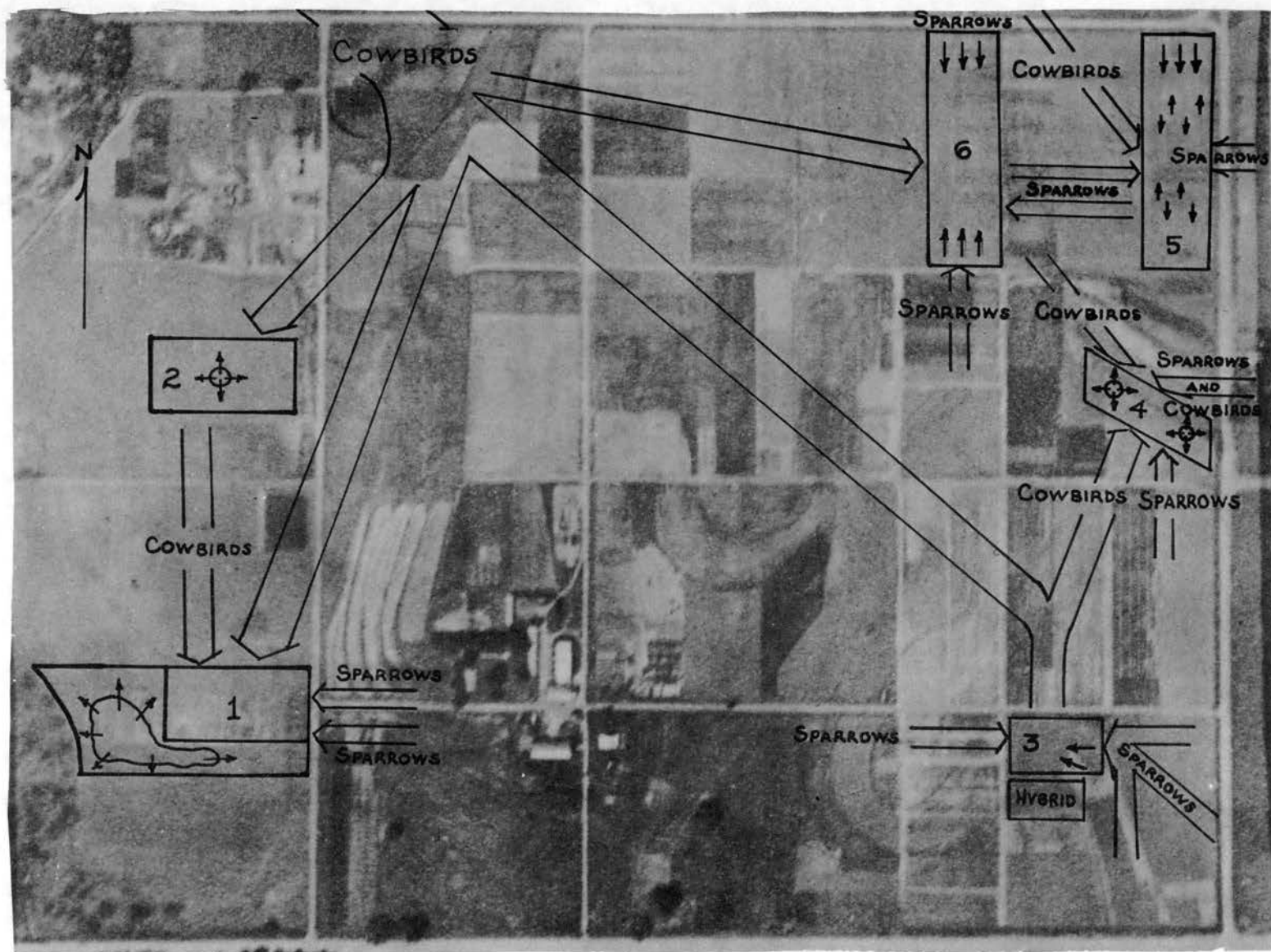


Figure 8. Travel lanes and bird approaches to standing grain plots.

TABLE VII  
BIRDS PRESENT IN FIELD PLOTS AT VARYING TIMES\*

Plot	Date	Sparrows	Cowbirds
West Kaffir	Aug. 1, 1958	450	25
	Aug. 7, 1958	300	0
	Aug. 8, 1958	600	0
	Aug. 13, 1958	0	0
	Aug. 21, 1958	20	200
	Aug. 31, 1958	50	300
	Sept. 6, 1958	0	0
	Sept. 11, 1958	200	15
	Sept. 15, 1958	50	150
	Sept. 16, 1958	100	3000
	Sept. 17, 1958	0	700
	Sept. 20, 1958	0	0
	Sept. 24, 1958	0	4000
	Sept. 29, 1958	0	0
	Oct. 1, 1958	25	1
East Kaffir	Aug. 8, 1958	150	0
	Aug. 19, 1958	300	200
	Aug. 23, 1958	0	1200
	Sept. 6, 1958	25	0
North Stillwater Bottom	July 27, 1959	75	0
	Aug. 1, 1959	25	25
	Aug. 2, 1959	150	150
	Aug. 5, 1959	0	140

TABLE VII (Continued)

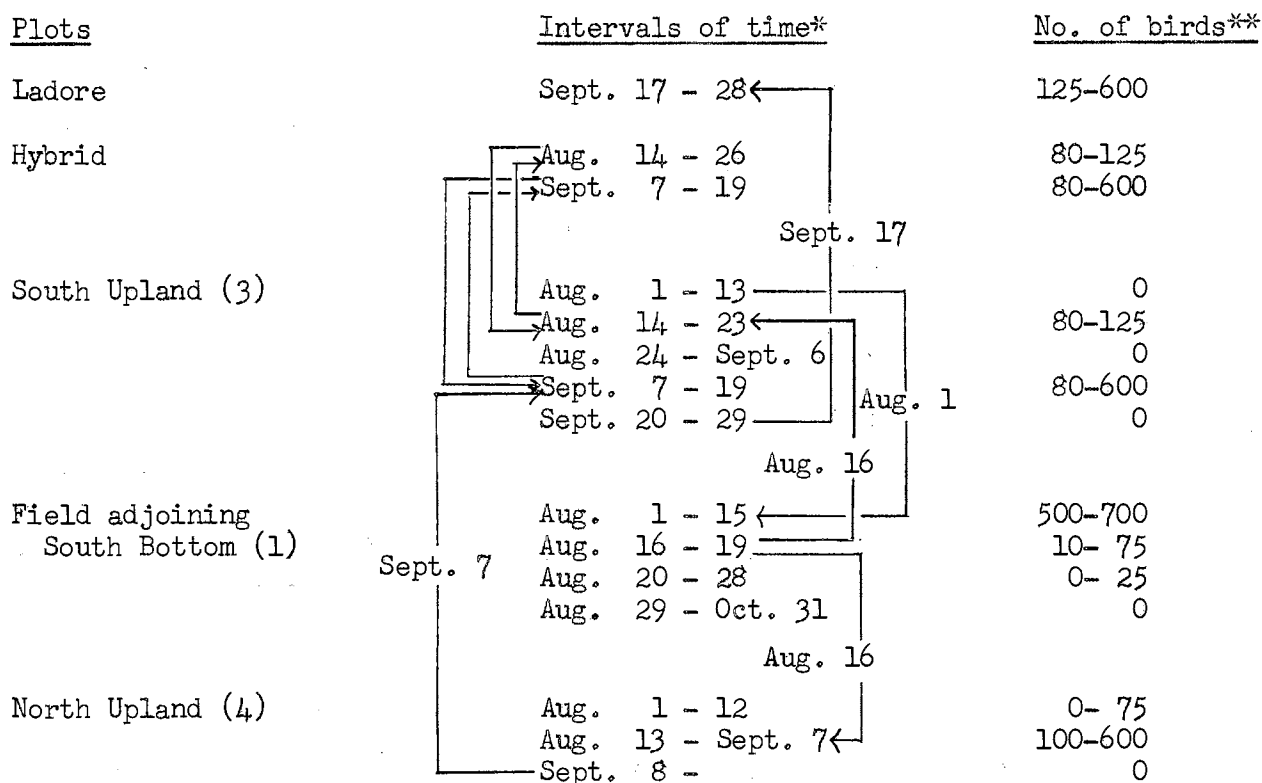
Plot	Date	Sparrows	Cowbirds
	Aug. 6, 1959	0	600
	Aug. 8, 1959	150	5000
	Aug. 11, 1959 to		
	Oct. 10, 1959	0	0
South Stillwater Bottom	Aug. 5, 1959	7	0
	Aug. 11, 1959	0	40
	Aug. 12, 1959	0	2
	Aug. 14, 1959	0	500
	Aug. 15, 1959 to		
	Oct. 10, 1959	0	0
South Stillwater Upland	Aug. 5, 1959	0	0
	Aug. 14, 1959	100	0
	Aug. 17, 1959	500	0
	Aug. 23, 1959	125	0
	Aug. 27, 1959	0	0
	Sept. 4, 1959	300	300
	Sept. 8, 1959	200	125
	Sept. 9, 1959	50	85
	Sept. 14, 1959	200	20
	Sept. 22, 1959	0	0
North Stillwater Upland	Aug. 5, 1959	30	0
	Aug. 14, 1959	125	0
	Aug. 16, 1959	600	0

\*Counts made by direct count or relative abundance count methods. (Wing, 1956).



area as the repellent plots during 1959, birds were noted feeding from the corners and borders of these small fields. This agrees with the 1958 observations.

Shifting of the feeding bird populations was very noticeable during 1959 (Figures 9, 10, 11 and 12). A sparrow population moved from the general region of plot 3 to the area around plot 1 on August 1, 1959, feeding there with a large population (5000<sup>±</sup>) of cowbirds. These sparrows then shifted their feeding to plots 3 and 4 (August 16, 1959). Part of the cowbirds also moved to plot 4 at the same time while others apparently migrated. By September 7, 1959, the grain in plot 4 was completely consumed. At this time, another part of this cowbird population apparently migrated and the balance moved to plot 3 along with the sparrows. Here, they fed only in the control of plot 3. There was at this time, a continuous exchange of sparrows between plot 3 and a nearby hybrid sorghum plot. The cowbirds were not seen to feed on the hybrid. A short time later (September 17, 1959), a variety of Ladore sorghum, to the south of plot 3, had ripened so the sparrows moved to it to feed while the remaining cowbirds migrated. Ladore sorghum is repellent to birds during the milk-dough stage, but from the above observations, it appeared to be more palatable during the hard dough stage than the variety planted in plot 3 or the treated grain. After the Ladore grain was all eaten (September 28, 1959), the sparrows dispersed with a few moving back into plot 3. Apparently, a Cooper's hawk kept them from feeding here for 10-14 days.



\*Period of time during the population of or absence of birds in a plot.

\*\*Range of the numbers of birds in a plot during the specified interval.  
Direction of movement with date of movement.

Figure 9. Interplot movement and populations of House Sparrows during testing periods.

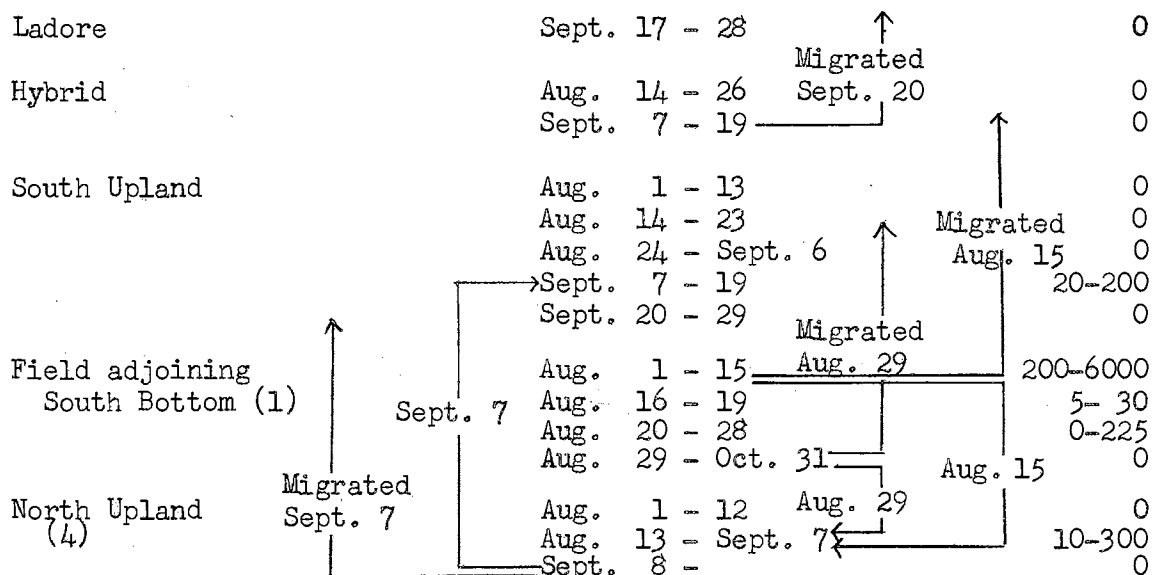


Figure 10. Interplot movement and populations of Cowbirds during testing periods.

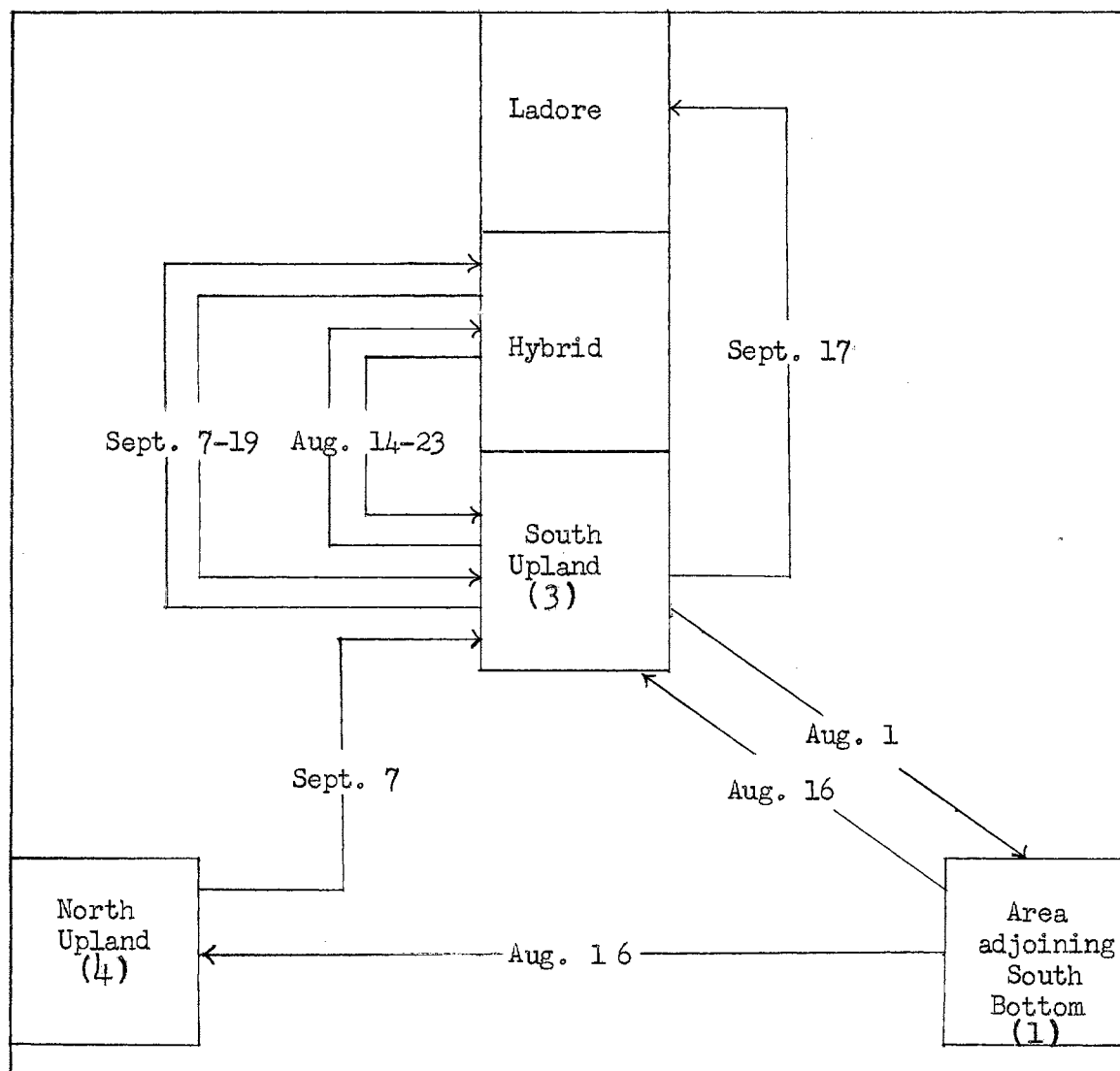


Figure 11. Interplot movement of House Sparrows during testing periods.

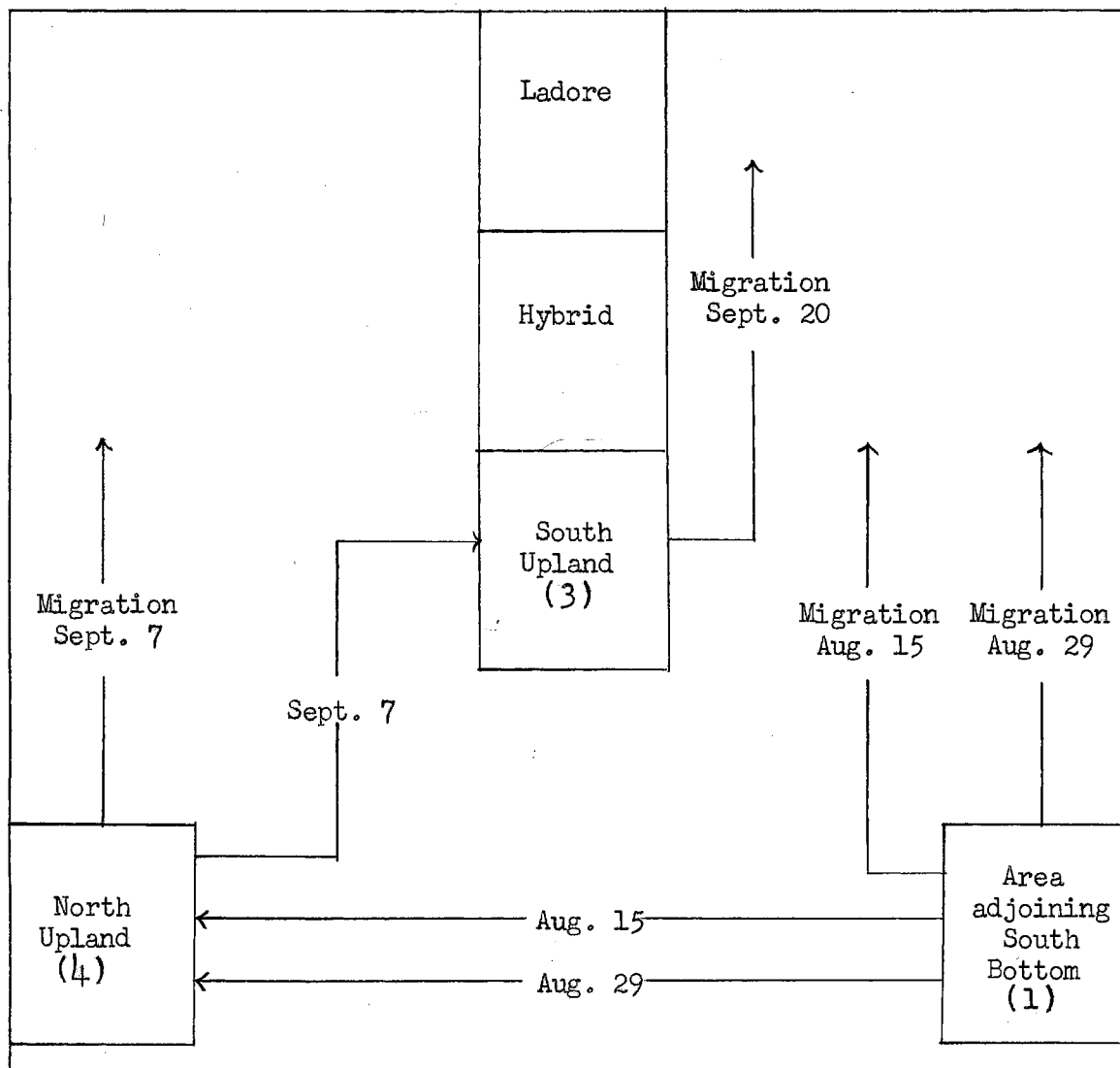


Figure 12. Interplot movement of Cowbirds during testing periods.

## MARKED BIRD STUDIES

The marking of birds with plastic neckties (collars) made possible a study of the range of birds moving from a trapping site out to feeding areas.

### Methods and Procedures

Birds were trapped in modified "S" traps and modified sparrow traps. Each bird was banded and a yellow plastic necktie was placed around its neck as a marker. During 1958, 67 sparrows and 192 cowbirds were banded and marked in this manner. In 1959, 614 sparrows and 14 cowbirds were marked. After having tried several other collars or neckties, one was devised that was best suited for the needs of this study. Plastic ribbon from the Cee Bee Company, Brooklyn, (not now available) or from The Stephens Company, Dallas, was used to make neckties. Figure 13 shows the materials, equipment, finished necktie and the necktie in place on the bird. The  $\frac{3}{8}$  inch ribbon was cut the desired length for each species to be marked. The plastic was notched where it circles the neck and two holes punched near the ends to fasten the necktie on the bird. E-Z eyelets (E-Z Buckle, Inc., New York) crimped with a Triumph belt punch (Sargent and Co.) were found most suitable for securing the necktie.

## Results of Observations

A total of 23,506 birds was counted during 367 observations at various times. Of this total number of birds, 244 were wearing neckties. The range of these birds from the trapping area can be seen on the map (Figure 14). Most of the marked sparrows observed ranged  $1/4 - 1/2$  mile of the trapping site. Several marked sparrows were observed at different times feeding on the Agronomy Farm two miles southwest of the traps. A marked male House Sparrow spent the winter at a suburban residence two miles north of the trap. A large population of sparrows at the Dairy Barn and another at the North Hog Barn did not contain any marked birds.

Table VIII gives data on bird observations in relation to trapping and marking.

It was very difficult to estimate the total number of birds feeding in the trapping area. However, an estimate can be made by the use of the Lincoln Index (Lincoln, 1930).

$$\frac{\text{number of marked birds seen}}{\text{total birds seen}} \times \frac{\text{total birds marked}}{\text{total birds coming to area}}$$

At no time were there more than 12 marked birds seen in a flock of 500. There were 614 birds marked in the area. To apply these figures to the index, the formula would appear thusly:

$$\frac{12}{500} \times \frac{614}{x}$$

According to this formula, 25,583 House Sparrows were feed-

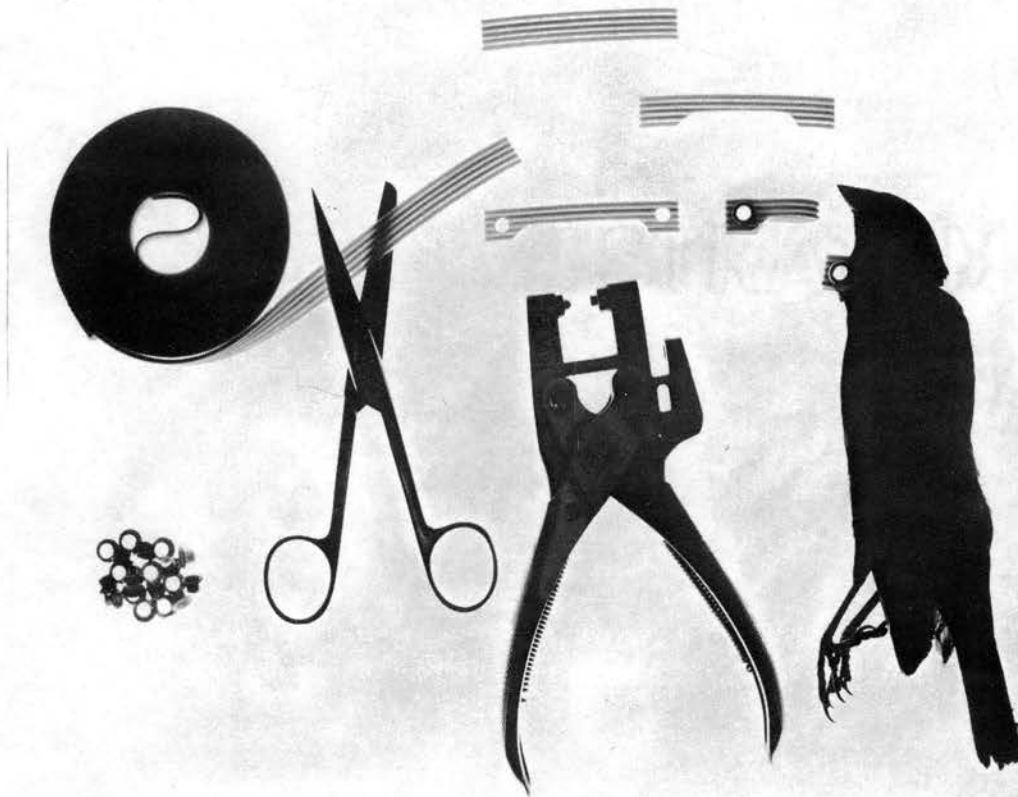


Figure 13. Equipment and method of making neckties (collars) for birds.

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ing in the area. It is surprising that there could have possibly been that many different individuals visiting the area. The number of marked birds may have been inadequate to make the use of this formula valid.

◀ Dairy Barn  
0-730

◀ Hog Barn  
0-1050

Sheep Barn  
0-332

◀ Anaplasmosis  
Lab.  
0-58

Agronomy farm  
0-120 14-998  
2-165

TO LAKE  
CARL BLACKWELL  
10 MILES

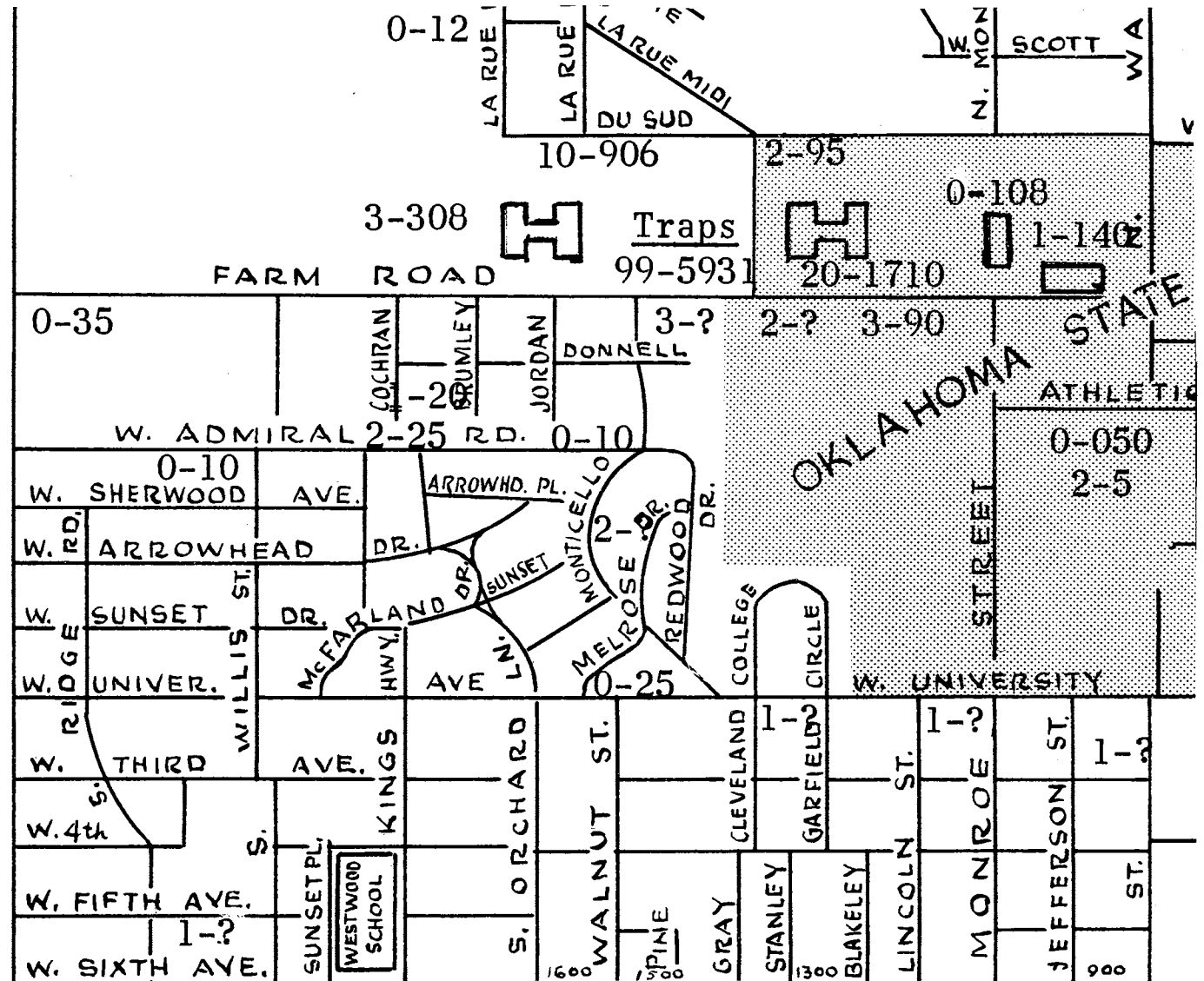


Figure 14. Range of marked birds (First No. = marked birds: Last No. = Total birds).



TABLE VIII  
DATA ON BANDED AND MARKED BIRDS

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	<u>Banded</u>
Sparrows	(1958) - 67 (1959) - <u>614</u> 681
Other Species	(1958) - 192 (1959) - <u>14</u> 206

	<u>Recaptures</u>
Sparrows	(1958) - 0 (1959) - 97
Other Species	(1958) - 8 (1959) - <u>1</u> 9

	<u>Dead</u>
Sparrows	(1958) - 3 (1959) - <u>7</u> 10
Other Species	(1958) - 3 (1959) - <u>2</u> 5

Percentages of Recaptures to Banded Birds

House Sparrow	(1958) = 0 - 67 (1959) = 97 - <u>614</u> 97 - 681 = 14.24%
Cowbirds	(1958) = 7 - 192 (1959) = 1 - <u>14</u> 8 - 206 = 3.88%

TABLE VIII (Continued)

Percentages of Reported Dead to Banded Birds

House Sparrow (1958) = 3 - 67  
 (1959) = 7 - 614  
 10 - 681 = 1.45%

Cowbirds (1958) = 3 - 192  
 (1959) = 2 - 14  
 5 - 206 = 2.427%

Totals of Reported Marked Birds to Total Numbers Seen

House Sparrow: 186 marked birds seen  
 13573 sparrows observed  
 = .0137 = 1.37%

Cowbird: 58 marked birds seen  
 9933 cowbirds observed  
 = .0058 = .58%

Percentages of the Total Banded Birds Seen to the  
Total Number Banded

House Sparrow: 186 marked birds seen (1958 & 1959)  
 681 bands (1958 & 1959)  
 = .2731 = 27.31%

Cowbird: 58 marked birds seen (1958 & 1959)  
 206 banded (1958 & 1959)  
 = .2815 = 28.15%

SUMMARY OF MISCELLANEOUS OBSERVATIONS  
AND FUTURE OUTLOOK OF RESEARCH

At the end of two years of research, 3522 miles traveled to and from plots, 2500 field observations made, and numerous pages of manuscript written, some progress has been made. Much more, however, needs to be done. Several aspects are open to investigation:

1. Expand and continue research begun in this study.
2. Check the effects and feasibility of spraying an entire area including plot, guard rows, fence row, shrubs, grassy areas, open ground, etc.
3. Check the effects of spraying bird roosts with repellents.
4. Check the effects of repellents on bird nesting areas. No repellency, nest desertion or death of young was noted when a number of House Sparrow nests were sprayed with Phillips 1281 and 1497 during various stages of incubation and brooding.
5. Test repellents by spraying chemicals on:
  - A. Peanuts. Much loss is caused by rodents and crows.
  - B. Watermelons and muskmelons.
  - C. Pecans. Heavy loss is caused by crows, jays and squirrels.

- D. Grapes. It was found in one test only that Phillips 1255 and Penick's B-5-2TV were very effective in repelling several species of fruit-eating birds from ripening grapes.
- E. Wheat and oats. Arasan 42-S and Phillips 1255 sprayed on guard rows were effective in repelling birds from small grain testing plots.
- F. Sunflowers. It was found that Phillips 1489 when sprayed on sunflowers did not repel House Sparrows.
- G. Soil. Spraying soil and germinating wheat with Arasan 42-S did not prevent rodent damage. In another test on oats, it did repel meadowlarks (Sturnella spp.). Phillips 5 sprayed on a field of combined grain did not repel House Sparrows.
6. Determine the reasons why more native fruits (e.g. Soapberry Sapindus Drummondii H. & A.] and Coralberry Symphoricarpos orbiculatus Moench) are not eaten by birds.

## SUMMARY

The objectives of this study were:

1. To develop tests to measure the effectiveness of certain chemicals in repelling House Sparrows and Brown-headed Cowbirds from standing grain crops.
2. To determine the feasibility of treating standing grain with chemicals in order to reduce bird damage.
3. To record and analyze the relationships between bird behavior and their feeding in grain fields.

New techniques were developed and described in detail. Measured amounts of chemically treated grain sorghum seed were placed in plastic sink strainers located at points where birds were concentrated. When candidate repellents were not effective the treated grain was all eaten within 24 hours; highly repellent materials prevented any measurable consumption of the grain during a seven-day period of testing. Forty-five chemicals were rated according to the degree of protection that each afforded.

Standing grain sorghum plots, one fourth to one half acre, were found to be a practical size for treatment with chemicals. Such plots provided a sufficiently large area to measure the effects of treatment upon grain products and the consumption of the grain by the birds. By excluding birds from a sample of the grain heads with selfing bags

it was possible to compare the weight of grain from areas:

1. Completely protected from both birds and the chemical.
2. Treated with the chemicals that rated highest in the pan tests.
3. Untreated portions of the grain plots.

Protection provided by the chemicals varied from 0 to almost 94 per cent. Chemical treatment apparently reduced the yield of grain up to 17.4 per cent.

The distance between the standing grain plots and the nearest site that afforded shelter from natural enemies and the weather appeared to have a marked effect upon the number and frequency of bird visits to the plot. House Sparrows seldom ranged out to feed as much as one-half mile from nesting and roosting areas. Brown-headed Cowbirds apparently moved greater distances between roosting and feeding grounds.

The presence of skillful bird predators such as the Cooper's Hawk appeared to greatly reduce the amount of bird activity in open exposed grain plots.

No chemical tested appeared to offer complete protection to standing grain from birds. However, several compounds, especially Arasan 42-S, 1255, 1275, 1489 and 1495, markedly reduced the amount of grain eaten by birds.

## BIBLIOGRAPHY

- Anonymous. 1845. Saltpeter and copperas as a repellent. Amer. Agriculturist, 4(4):11.
- Anonymous. 1877. Use of lime or gypsum on corn to protect from birds. Country Gentleman, 42:268.
- Anonymous. 1881. Note on use of red lead as a bird repellent. Amer. Agriculturist, 40:140.
- Barrows, Walter B. 1889. The English Sparrow in North America; especially in its relation to agriculture. U. S. Dept. Agric., Div. Econ. Ornith. and Mammal., Bull. No. 1.
- Barrows, W. B. and E. A. Schwarz. 1895. The common crow in the United States. U. S. Dept. Agric., Div. Econ. Ornith. and Mammal., Bull. No. 6.
- Beal, F. E. L. 1900. Food of the Bobolink, blackbirds and grackles. U. S. Dept. Agric. Biol. Surv., Bull. No. 13.
- Beal, F. E. L. 1904. Some common birds in their relation to agriculture. U. S. Dept. Agric. Farmers' Bull. No. 54:18.
- Butterfield, H. M. 1947. Control of birds. California Cultivator, 94:404.
- Cieslar, A. 1886. Effect of red lead, carbolic acid and petroleum on germination. Forestry Jour., 11:16.
- Dahms, R. G., J. B. Sieglinger and W. D. Guthrie. 1955. Methods of treating sorghum selfing bags for insect control. Jour. Econ. Ent., 48(5):568-572.
- Dambach, Charles A. and D. L. Leedy. 1948. Ohio studies with repellent materials, with notes on damage to corn by pheasants and other wildlife. Jour. Wildlife Mgmt., 12(4):392-398.
- Dambach, Charles A. and D. L. Leedy. 1949. Prevention of crop damage by pheasant. Trans. Fourteenth N. Amer. Wildlife Conf. :592-603.

- Damon, David. 1933. Do pheasants damage grain crops? Natl. Waltonian, 1(5):5-11.
- Fowle, C. D. 1944. Analysis of game damage problems in the Duncan area of Vancouver Island, B. C. Univ. British Columbia (mimeographed).
- Gilfillan, Merrill G. 1958. Down came a blackbird and pecked off an ear. The Ohio Cons. Bull., 22(1):10-11.
- Griffin, Daude N. and F. M. Baumgartner. 1959. Evaluation of certain chemicals as bird repellents. Proc. Oklahoma Acad. Sci., 39:78-82.
- Hamrum, Charles L. 1953. Experiments on the senses of taste and smell in the Bob-white Quail (Colinus virginianus virginianus). Amer. Midland Nat., 49: 872-877.
- Hockenyos, G. L. 1958. Bird repellent compositions and their modifications for use as animal and insect entanglements. Natl. Pest Control Ass'n. Tech. Release No. 8-58.
- Kalmbach, E. R. 1928. The European Starling in the United States. U. S. Dept. Agric. Farmers' Bull. No. 1571: 12-15.
- Kalmbach, E. R. 1943. Birds, rodents and colored baits. Trans. Eighth N. Amer. Wildlife Conf. :408-416.
- Kare, Morley R., Robert Black and E. G. Allison. 1957. The sense of taste in the fowl. Poultry Sci., 36(1): 129-138.
- Lincoln, F. C. 1930. Calculating waterfowl abundance on the basis of banding returns. U. S. Dept. Agric. Circ. No. 118.
- Mann, W. F. and H. J. Derr. 1955. Not for the birds. Forests and people, 5(3):32-33.
- Neff, Johnson A. and Brooke Meanley. 1956. Research on bird repellents. U. S. Fish & Wildlife Serv. Prog. Rept., 1:3, 8.
- Neff, Johnson A. and Brooke Meanley. 1957. Blackbirds and the Arkansas rice crop. Arkansas Agric. Expt. Sta. Bull. 584:63-65.
- Pearson, G. A. 1913. Methods of combating seed-destroying animals. Rev. Forest Serv. Investigations, 2:82-85.



Steele, John. 1959. Job completion report Aug. 15, 1959.  
Oklahoma Dept. Wildlife Cons.

Thomas, H. F. 1954. Some tried and suggested methods for  
attempted control of starlings. Mildura District  
Council of the Australian Dried Fruits Ass'n., Mildura.

VanTyne, Josselyn and Andrew J. Berger. 1959. Fundament-  
als of Ornithology. John Wiley and Sons, Inc. New  
York: 113-114.

Wing, Leonard W. 1956. Natural history of birds. Ronald  
Press. New York: 246-247.

## APPENDIX

### A List of Chemicals Used in This Study

<u>Code</u>	<u>Chemical</u>
9	3-Chloro-4-hydroxysulfolane
26	Phenylsulfenyl piperidine
149	4-Phthalimido-2,6-dimethylpyrimidine
493	Phenylsulfenyl morpholine
564	<u>tert</u> -Butylsulfenyl pentamethylene-dithiocarbamate
749	2,4-Hexadiyne-1,6-diol
751	2,7-Dimethyl-3,5-octadiyne-2,7-diol
790	Crotonaldehyde cyanohydrin
885	Chlorinated xylenes
888	1,6-Chloroacetoxyhexane
978	Methyl bis(cyanoethylamine)
1058	N,N-Dimethyl <u>tert</u> -octylsulfinamide
1215	Dibenzyl sulfoxide
1217	4,5-Diamino-2-ethylmercaptopyridine
1256	N,N-Pentamethylene <u>tert</u> -octyl sulfinamide
1265	Pyridine N-oxide
1266	Quinoline N-oxide dihydrate
1267	4-Methoxypyridine N-oxide
1273	N,N-Di- <u>n</u> -butyl methyl sulfinamide
1274	N,N-Diisopropyl <u>tert</u> -octyl sulfinamide
1275	N,N-Di- <u>n</u> -butyl <u>tert</u> -octyl sulfinamide

<u>Code</u>	<u>Chemical</u>
1281	N-Ethyl bis( <u>tert</u> -octylsulfinamide)
1323	Ethoxyethyl <u>n</u> -octyl sulfoxide
1353	$\beta,\beta'$ -Dicyanoethyl thioether
1383	3-Hydroxybutyl $\alpha$ -chloroacetate
1489	N,N-Di <u>n</u> -butyl phenyl sulfinamide
1495	<u>n</u> -Butylthiosulphenyl <u>n</u> -butyl trithiocarbonate
1497	Di- <u>n</u> -butyl pentasulfide
1509	Tri- <u>n</u> -butyl trithiophosphate
1566	4-Chloropyridine-N-oxide

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