November 1976

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An accurate economic analysis of pest species, such as birds depredating agricultural systems, would entail a thorough understanding of the species[1] ecological relationships with all components of their environment. Understanding behavioral patterns (e.g., seasonal territorialism and gregariousness, reproductive characteristics, and annual food habits), population dynamics (e.g., natality, mortality, and sex ratios), and environmental pressures (e.g., carrying capacity and interspecific competition) would only begin to provide a base for a valid evaluation. No single parameter could integrate the complex interactions which affect agricultural production. However, evaluation of one such parameter, food habits analysis, could provide enough useful information for estimating one aspect of economic pressure, the direct crop losses resulting from avian agricultural depredation.

This study was an economic evaluation of the Redwing, Starling, and Cowbird, in relation to agricultural production and crop yield in north-central Ohio during the late summer and early fall of 1974. The evaluation was limited to projecting direct dollar losses based solely on the species[1] food habits. No attempt was made to measure actual damage, as was done by Ogden (1969) and others (Anon., 1974; Anon., 1975; Winters, 1973). Further, findings from this three-month study could not be extrapolated to the entire year, since food habits shift according to changes in seasonal food availability.

Study Area

This study was conducted during the 1974 summer-fall flocking season along the southern edge of Lake Erie where extensive agricultural depredations have been reported (Anon., 1974; Anon., 1975). Collections were made at the Winous Point Shooting Club, about 5 miles southwest of Port Clinton in Ottawa County, and at the Northcentral Branch, Ohio Agricultural Research and Development Center, about 15 miles southwest of Sandusky in western Erie and eastern Sandusky Counties. Both areas, characterized by a combination of marsh lands, open fields, and cornfields, were located within an important concentration area for Blackbird flocks. Meanley (1974) estimated a 1973 blackbird population of about two million birds distributed among ten roosts along the Lake Erie marshes between Toledo and Huron, Ohio; four of the roosts were located in the vicinity of the study areas. The largest roost, an estimated one million birds (65% Redwing, 15% Cowbirds, 15% Starlings and 5% Grackles), was located in the marshes of the Ottawa Gun Club, approximately 4 miles south of Winous Point and 20 miles west of the Research and Development Center.

METHODS AND MATERIALS

Collection and Laboratory Analysis

Specimens were gathered three times weekly from 1 August to 1 November, 1974, primarily along flyways between roosting and feeding areas. Collecting times and locations were selectively chosen to obtain representations of all foods being utilized. Records were kept on all specimens: sex and approximate age, determined from plumage characteristics and/or internal sex organs; date and location of collection; time of day; and general flocking conditions (i.e., size and flight direction).

All specimens were returned to the laboratory where body weights were taken and the esophagous, proventriculus, and gizzard were removed together, weighed, and placed immediately into preservative. Later dissection of the esophagous-proventriculus-gizzard complex (hereafter referred to as the stomach) revealed the contents, which were then visually separated, identified, and grouped as follows: injurious, beneficial, and unclassfied animal matter; corn, other agricultural, non-agricultural, and unidentified plant matter. Grit content was removed and excluded from all measurements and analytical computations.

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External moisture from the plant matter was removed by blotting, and volumes were measured by liquid displacement to the nearest 0.01cc in a 0.5cc syringe. Due to difficulty in submerging many insect fragments, the volume of the animal matter, relative to that of the plant matter, was estimated visually. Only total samples exceeding 0.05cc were included in this analysis.

Mathematical and Statistical Analysis

Data for each species were represented using a combination of frequency-occurrence, per cent-occurrence, and aggregate volume measures (Williams, 1975). Percentage data for each age and sex classification within each species were compared using a Basic 1 computer program (Sokal and Rohlf, 1969). Equivalent volume measurements were hand calculated and similarly compared.

Damage Determinations

An estimation of the direct dollar damage to agricultural production by the different species was based on established assumptions and calculations. First, since volume displacements in the food study were all performed using water and since the food items contained a high proportion of water, the specific gravity of the food was assumed to approximate that of water. Thus, diet was determined by assuming that a 1cc displacement approximated 1g and then calculating volume-weight statistics.

Second, total daily consumption, in terms of per cent body weight, was assumed to approximate that suggested by Dorst (1974). He reported that terrestrial birds whose weights ranged between 10g and 90g ate between 10 and 30 per cent of their body weight daily; the smaller the bird, the proportionately greater its daily consumption.

Calculations of daily consumption, as a measure of per cent of body weight, were then made using Formula 1, which was derived from the finding of Dorst (1974). Values were determined for each species involved.

$$\text{Daily Consumption (as \% body wt)} = a - \frac{(r)\ (\bar{X} - b)}{r^1} \qquad (1)$$

where,

a = max % body wt consumption (30%)
b = min body wt (10g)
r = range of body wt consumption (30% - 10%)
r^1 = range of body wt (90g - 10g)
$\bar{X}$ = mean body wt.

This measure was multiplied by the average body weight of each species to obtain the total individual daily consumption in grams. The resulting values were subsequently multiplied by the local four-roost population numbers, estimated by Meanley (1974), to obtain an appraisal of the overall population's dally consumption. Total population consumption of corn, wheat, and grapes was then calculated, based on per cent representation of the items within each species' diet.

Finally, estimated bushel or ton and dollar depredatory loss values were determined using standard U.S.D.A. conversions and the crop market values at the time of the 1974 harvest (Ohio Crop Reporting Service, 1975). The per cent of crop loss was determined by dividing the total bushel or ton yield by the sum of the total bushel or ton yield and the estimated bushel or ton depredatory loss (Formula 2):

$$\text{Per Cent Loss} = \left(1 - \frac{Y}{Y + L}\right) \times 100 \qquad (2)$$

where,

Y = total crop yield (bu or ton)
L = estimated depredatory loss (bu or ton).

RESULTS AND DISCUSSION

A pictorial summary of the food habits of the Redwing, Cowbird and Starling is illustrated in Figure 1. A detailed analysis of these findings was reported by Williams (1975). Agricultural products, primarily wheat and corn, accounted for a substantial portion of both the Redwing and Cowbird diets (73.9% and 54.8%, respectively); corn was especially important in the Redwing diet (70.8%). The Starling diet was composed of only 28.3 per cent agricultural products, mostly grapes. In contrast, non-agricultural products, a relatively unimportant component in the Redwing diet, constituted a high proportion of the diet in both Starlings and Cowbirds (33.7% and 25.9%, respectively). Animal matter was of significant importance only in the Starling diet, constituting over 30 per cent.

Over one-half of the combined diets of all the species consisted of agricultural products, reflecting the great proportion in both the Redwing and Cowbird diets (Figure 1). Corn was the most utilized food type (36.6%), again reflecting the significant proportion in the Redwing diet. Non-agricultural products and animal matter each represented a relatively low constituent of the combined diets.

As a part of this seasonal evaluation, basic parameters had to be defined and sources of variation identified. The overall content analysis possibly may have been biased toward harder food items due to post-mortem digestion and to the inclusion of gizzard contents (Bartonek and Hickey, 1969; Swanson and Bartonek, 1970). This suggested that the representation of harder seeds and heavily chitonized animals might have been overemphasized. In contrast, representation of softer items, such as milk and dough stage corn, might have been underestimated.

The information presented in Table 1 represents economic values, based on the food habits information, for three counties in north-central Ohio -- Ottawa, Sandusky and Erie. The simple extrapolation of data was based on several assumptions. First, population fluctuations were known to occur; flock and roost sizes increased and peaked, then gradually decreased with the onset of migration. Fluctuations occurred dally, with birds shifting from one area to another. Since population estimates throughout the season were not available, the early September, 1973, estimates of the four local roosts within these counties (Meanley 1974) were assumed to represent a population average for the entire three-month study period.

Second, the food intake, based on the calculated daily consumption rate per bird, was assumed to be an average value, and the proportions of food consumed during the afternoon and early evening just prior to specimen collection were assumed to be representative of the daily consumption. The latter was supported by findings of Hintz (1968) who indicated that in the fall intensive feeding by the Redwing on plant material, primarily corn, began about 0730 and remained fairly constant throughout the day.

Third, the source of corn was assumed to be standing fields in the milk or dough stages because corn rarely was used as a livestock feed in the areas studied, and corn found in the stomachs often was soft but whole kernels. In addition, consumption of corn by the birds noticeably dropped by October, corresponding to the occurrence of the early dent stage and subsequent harvesting. The source of wheat was considered to be livestock feedyards where wheat was readily accessible and because few observations of feeding were in areas with vagrant wheat. Sources of grapes were not determined, but complaints by local grape growers suggested that cultivated plants were quite likely.

The Redwing was responsible for nearly 80 per cent of all agricultural losses in these three counties (Table 1), primarily because of an estimated 4.5 fold greater population size than either of the other two species (Meanley, 1974); Cowbird and Starling depredation accounted for approximately 12 and 8 per cent, respectively. An overall assessment suggested that, on a populational basis over the three month depredatory period, approximately $87,000 worth of agricultural crops were lost to these species in the Erie, Ottawa, and Sandusky marsh-perimeter areas. Most of the losses were attributed to Redwings and their depredation on corn; Cowbirds and Starlings were of considerably less importance.

The extrapolations from the data collected suggested that corn was the crop receiving the greatest bird pressure, a $775 or 218 bu loss per day. Ninety-two per cent of all corn losses was attributed to the Redwing, again, primarily because of a substantially greater representation of corn in its diet and a greater population size. The season's estimated corn depredatory loss was over 20 thousand bushels and amounted to 0.27 per cent of the 7.3 million bushel total combined yield for all three counties. Based on findings by Dyer (1967) and Mott, et al. (1972) and on observations during this study, depredation was considered to be much higher within two or three miles of the marshes, the primary feeding areas. This 0.27 per cent depredatory loss therefore may have been higher due to the restricted geographic area.

The damage values for corn obtained using stomach content analysis represented only a third of the amounts estimated for the same three counties, using direct field assessments (Anon. 1974) (Table 2). The differences may be attributed to a number of factors. First, any combination of the above mentioned sources of variation within the food habits technique might result in an underestimation. Second, the corn represented in the diets may have come from just the marsh-perimeter areas rather than from the entire three county area. This geographic restriction would concern only a portion of the total three-state corn production and would result in the overall per cent depredatory loss being greater. Third, the food habits technique differentiated between relative pressures from

different species, and was consequently restricted to only the species studied -- Redwings, Cowbirds, and Starlings. Other species possibly also involved in corn depredations and not collected for this study were consequently not considered, thus possibly making the damage estimates low. For example, findings made by Williams (1975) in north-central Ohio suggested that corn may be a substantial portion (32%) of the common grackle diet, which was not included in this evaluation. Therefore, an additional 500 bu of corn loss (similarly determined as for the species studied in this evaluation) might have been attributed to grackles.

Both evaluation methods may serve as a tool within their own limitations. The field assessment technique, unlike the food habits technique, provides specific field or county visual damage evaluation, which may incorporate both consumption damages and reduced product marketability. Similarly, secondary damage resulting from disease and/or mildew can be determined using the field assessment technique; however, past field damage surveys have suggested that such damage usually is of little importance (Anon., 1974; Ogden, 1969). The food habits technique, on the other hand, allows for partitioning of agricultural depredatory pressures according to the species involved, a measure which is not possible with the field assessment technique. Data of the food habits technique also represent actual food consumption, and hence an indication of actual depredation, rather than field assessment based on a relationship between "potential" and "actual" yields. Finally, while the food habits technique of estimating bird depredation may be an underestimation because all species cannot be sampled, the field assessment technique may lack the <???>imination of the food habits technique and result in an overestimation of bird pressure. The field assessment technique therefore should be considered for evaluation of actual standing crop damage, while the food habits technique should be considered an appropriate tool for the understanding of specific avian feeding pressures on agricultural production.

SUMMARY

An economic evaluation of Redwings, Starlings, and Cowbirds, during a late summer and early fall flocking season, was conducted using dietary information and extrapolations. Agricultural depredation was determined based on daily food consumption, as a measure of per cent of body weight, and extrapolated according to the estimated population size.

Agricultural products, primarily corn, wheat, and grapes, accounted for 73.9% 54.8%, and 28.3% of the Redwing, Cowbird, and Starling diets, respectively. Over one-half of the combined diets of all three species consisted of agricultural products. Corn was the most utilized food item, accounting for 36.6% of the combined diets, primarily due to the high percentage of corn (70.8%) in the Redwing diet. These depredating birds were estimated to consume $775 or 218 bu of corn per day in a three-county area. The season's estimated corn depredatory loss was over 20 thousand bushels and amounted to 0.27 per cent of the 7.3 million bushel total combined yield for all three counties. The damage values for corn attained, using extrapolations from the stomach content analyses, represented only one-third of the amounts estimated using direct field assessments.

A consideration of the roles of these two evaluative methods suggests that the field assessment technique should be considered for evaluation of actual standing crop consumption, aesthetic and secondary damages. The food habits technique, on the other hand, should be considered for evaluation of specific avian feeding pressures on agricultural production.

ACKNOWLEDGEMENTS

I wish to extend my sincere appreciation to Thomas Stockdale (Wildlife Specialist, Ohio State University) and Dr. Robert Meeks (Manager, Winous Point Shooting Club) for providing access to collecting areas. This study was made possible, in part, by the financial assistance from the Department of Biological Sciences and the Environmental Studies Center, Bowling Green State University, and the National Science Foundation.

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TABLE 1. Economic comparisons, based on food habits information, of the Redwing, Starling, and Cowbird in relation to agricultural depredation in a three-county area in north-central Ohio.

	Redwing	Starling	Cowbird	Total
Average Body Weight (g)	65.6	84.4	48.1	
Consumption Rate (% Body wt.)	16.1	11.4	20.5	
Daily Consumption/Bird (g)	10.5	9.6	9.9	
Estimated Population Size ($x10^3$)	686.0	154.0	152.5	992.5
Daily Pop. Consumption (lb)	15880.0	3259.3	3328.4	22467.7
Corn (lb)[4]	11243.0	107.6	872.0	12222.6
Wheat (lb)[4]	397.0	355.3	931.9	1684.2
Grape (lb)[4]	95.3	400.9	0.0	496.2
Total agr. products (lb)	11735.3	863.8	1903.9	14403.0
Estimated Loss/Day				
Corn (bu)[2]	200.8	1.9	15.6	218.3
Wheat (bu)[2]	6.6	5.9	15.5	28.0
Grape (ton)[2]	<0.1	0.2	0.0	0.2
Estimated Dollar Loss/Day	761	77	119	947
Corn[2]	713	7	55	775
Wheat[2]	27	25	64	116
Grape[2]	11	45	0	56
Estimated Loss/Season				
Corn (bu)[3]	18473.6	174.0	1435.2	20083.6
Wheat (bu)[3]	607.2	542.8	1426.0	2576.0
Grape (ton)[3]	4.6	18.4	0.0	23.0
Estimated Dollar Loss/Season				
Corn[2]	69122	6959	11013	87093
Wheat[2]	65581	621	5095	71297
Grape[2]	2520	2259	5918	10691
	1021	4086	0	5106

[1] 1 lb = 454 g
[2]corn = 56 lb/bu @ $3.55/bu
wheat = 60 lb/bu @ $4.15/bu
grape = - @ $222.00/ton
[3]Aug. 1 - Nov. 1 (92 days)

TABLE 2

Comparisons of estimates of primary damage to corn in 1974 attributed to "blackbird" depredations in north-central Ohio using food habits and field assessment techniques.

	Field Assessment[1]		Food Habits[2]	
	bu	%	bu	%
Erie	11,000	0.64	-	
Sandusky	19,000	0.77	-	
Ottawa	32,000	2.50	-	
TOTAL	62,000	0.93	20,094	0.27

[1]bushel estimates per county recalculated from Anonymous (1974).
[2]estimates calculated using food habits information and crop statistics from the 1974 annual report of the Ohio Crop Reporting Service; estimates were based on the entire area of all three counties rather than by individual county.

Fig. 1: Percentage of total stomach volume comparisons of Redwing, Cowbird, and Starling diets.