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Crop depredation by blackbirds (Icteridae) and Starlings *(sturnus vulgaris)* in North America has long prompted experimentation with control techniques. These efforts have been centered in the northeast and northcentral United States where concentrated cultivation of vulnerable crops coincides with the location where flocks of blackbirds congregate in the fall prior to their migration south (Stone, et al., 1972; Wiens and Dyer, 1975). In these areas the high cost and logistic impracticality of implementing widespread controls has suggested the need for modifying agricultural practices instead (Wiens and Dyer, 1975).

More recently, attention has been focused farther south, particularly in Kentucky and Tennessee where winter roosts of mixed flocks of blackbirds and Starlings commonly number over several million birds. These highly localized concentrations have prompted concern for both agricultural damage and danger to human health (Department of Army, 1975). A major difference between the problem in the South and that farther north is that in the South the birds present themselves as much more accessible targets for control measures. By virtue of their tremendous concentrations they make the potential for large scale extermination very real. It is quite conceivable that a significant proportion of the entire North American populations of these birds could be eliminated if extermination efforts were maintained for several years at the major winter roosts.

Before such extermination is allowed to proceed, a number of questions must be answered. These can be divided into two areas. The first area deals with whether or not the control measures are actually justified--how much agricultural damage is done by the birds and how real is their threat to human health? The second area of questioning concerns the environmental impact of both the control measures themselves as well as the effect of suddenly removing such large numbers of birds from the ecosystem. This paper presents the results of a preliminary study aimed not at answering these questions so much as providing some insight into the factors which must be considered if accurate answers are to be obtained.

STUDY SITE AND METHODS

A blackbird roost located on the cantonment area of the U.S. Army base at Fort Campbell, Kentucky was selected for study due to the large size of the flock involved, its focus of impending control measures, and the availability of background information in the form of flock size estimates, history of the roost and estimates of impact of the flock on surrounding agricultural areas. The size of the flock had been estimated to include 4 to 5 million birds during the period December 1974 to mid-January 1975 (Department of Army 1975), By late January the flock size was thought by local land management personnel to be perhaps only 2/3 to 3/4 of its December size. The roost area was in a pine *(pinus taeda)* plantation approximately 11 ha in area. Scattered deciduous trees within and at the edges of the plantation were used for staging and for roosting of some species. All information was collected by a five-man team during a three-day period from January 18 to 20, 1975.

Flock composition

Three techniques were employed to determine relative abundance of species in the flock. The first involved a road census method during the day when the birds were foraging away from the roost. A random course was driven along roads within 20 km of the roost. With the aid of binoculars the species composition and approximate size of all blackbird flocks were recorded. A distance of 64 km was driven.

The second technique involved strip census counts of dead birds within the roost area. These were birds which had apparently died of natural causes and had been accumulating since the initiation of roosting activity in the fall. Each strip was 5 metres wide and approximately 50 metres long. An attempt was made to sample all areas of the roost. Every carcass within the strip was identified to species, sex (where possible), and state of decomposition. The last characteristic was classified on a scale of 1 to 4 with the latter representing a bird which had recently died with virtually no decomposition, while individuals classed as 1 were so badly decomposed that carcasses were incomplete and only plumage remnants allowed identification.

The final technique employed was sampling birds from the roost at night using a shotgun. Sampling was carried out on two nights. The first night individuals from all shots taken were counted together, while on the second night separate counts were kept for each shot and the shot locations marked on a map of the roost.

Diet Information

The crops and gizzards of all birds shot on the two sampling nights were removed and individually stored in alcohol. The contents of each were examined under a dissecting microscope and the percent by volume of each identifiable constituent was estimated. The samples were oven-dried at 50° C for 24 hours and weighed. Weed seeds and insects were identified by experts at Agriculture Canada.

Non-pest Species

A period of one hour was spent by three observers in the roost and in the mixed deciduous woodlot and open field within 200 metres of the roost area. With the aid of binoculars all birds were identified, and the number of each species recorded.

RESULTS

The results of the three sampling techniques used to estimate the species composition of the flock are presented in Table 1. Also included are the results of two sampling efforts performed at the same roost by the Army, as published in their environmental impact statements (Department of Army 1974 and 1975). The variability both within and between techniques is very striking. Of particular interest is the fact that Army sampling failed to detect the presence of Rusty Blackbirds *(Euphagus carolinus)* in the flock. A possible explanation, other than sampling error, could be that this species had begun using this roost after the Army sampling date. However, a breakdown of the dead bird strip counts (Table 2) indicates that Rusty Blackbirds occurred in three of the four decomposition classes, suggesting that they had been present at the roost for some time.

In order to get an indication whether flock composition might change markedly over the roosting season, dead bird counts from the strip census technique have been arranged into decomposition classes in Table 2. Although causes of death and specific decomposition rates are unknown, a general trend appears evident. Assuming roost mortality reflects the relative abundance of species present, there seems to have been a gradual replacement of Grackles *(Quiscalus quiscula)* by Starlings, or at least an increase in the relative abundance of Starlings, if the flock had been increasing in size. The results at least suggest that the flock size and/or species composition may be very dynamic over the course of the roosting season.

In the shotgun sample on January 19, 273 birds were collected with 17 shots. Figure 1 presents the results of the analysis of flock composition by shot, indicating as well the location of each shot in the roost. This analysis clearly indicates how a sample could be greatly biased if sampling were confined to a particular area of the roost. This is further borne out by Table 3 in which the species composition of shots has been determined by tree type and shot location. Included in the table are the number of birds per shot for each area, giving some indication of roosting density.

The results of the crop and gizzard analysis are presented in Table 4. The percent by volume values have been used to separate total dry weights into constituent parts. Of the identifiable contents, it should be noted that over 30% consisted of weed seeds and animal matter. Tables 5 and 6, respectively, present the identification of the weed seeds and animal matter, with the former also being broken down by the bird species in which they were found. Although the identification of animal matter content has not been quantified on a species basis, it is notable that much of the animal matter in the bird stomachs was comprised of economically important insect pests.

The results of the survey for non-pest species in the roost vicinity are presented in Table 7. The fact that 17 species of birds were observed in only three man-hours inside and within only 200 metres of the roost area is in striking disagreement with the results of a similar survey by the Army (Department of Army 1975). They report that no non-pest species of birds were seen in the blackbird roost.

DISCUSSION

During the winter of 1974-75, a flock estimated to consist of approximately 5 million blackbirds, including Starlings, Red-winged Blackbirds *(Agelaius phoeniceus)*, Grackles, Rusty Blackbirds, and Cowbirds *(Molothrus ater)* roosting in the cantonment area of Fort Campbell, Kentucky became the focus of control measures by the U.S. Army (cf. Department of Army 1975). Based on the premises that the blackbird roost constituted a health hazard (due to possible histoplasmosis), an agricultural nuisance, an inconvenience to local residents, and a possible hazard to aircraft, the U.S. Army sought to control this flock of blackbirds and accordingly filed an Environmental Impact Statement (EIS) (Department of Army 1975). The emphasis of this impact statement was on the negative effects of the blackbird roost in its immediate environment and on the possible impact on the roost and surrounding environment of the control effort *per se,* that is, the spraying of Avian Stressing Agent PA-14 (Tergitol 15-S-9).

Little if any consideration was given to the possible long-term consequences of removing large numbers of blackbirds from their breeding habitats. As was pointed out by the senior author, and by several others in letters commenting on the Draft EIS, the beneficial effects of having the birds consume insect pests, weed seeds, and waste grain may signficantly counter-balance any economic losses attributable to the blackbirds. Severe reduction of blackbird numbers may be accompanied by increases in populations of insect pests, such as army worms and corn borers (cf. Table 6) and weeds, as well as rodent populations which would be released from competition with blackbirds for the waste grain left by mechanical harvesters. It seems obvious that both sides of the economic and ecologic ledger must be completed if a valid statement of the impact of any major environmental alterations is to be obtained.

Even within the context of issues and information considered in the EIS regarding the control of winter blackbird roosts, the present study has revealed discrepancies and inadequacies that demand attention before extensive control is allowed to become routine as threatened by recent legislation (Jackson, 1976). Dietary differences between species require that accurate information on the type and quantity of food consumed by each species, and the relative abundance of each species in the flock, be determined before estimates of economic losses are valid. A single sample per winter season to determine diet and flock composition is inadequate, because both the size and composition of a given flock are subject to continual change, as is the availability and consequently the use of various food types. For example, our study showed that in late January, the Fort Campbell blackbird roost was composed of between 2 and 9 percent Rusty Blackbirds, whereas sampling by the army 9 days earlier failed to reveal the presence of this species. Whether Rusty Blackbirds had very recently begun using this roost (unlikely as mentioned earlier, cf. Table 2), or the clumped dispersion of species within the roost (Fig. 1) resulted in the failure of the Army sampling to collect this species, it is obvious that insufficient sampling prior to the control operation led to errors in determining environmental impact of the birds and their control.

Similarly, extrapolation of annual economic losses based on a sample of the birds diet on a single day in December does not account for the shifting pattern of food availability and use. Wheat and corn that may have been taken from fields in December was no longer available in late January, consequently diets had compensated by shifting to other food sources. Continual monitoring of the diets of each species, and the relative abundance of each species in the flock, is essential to provide a meaningful estimate of the extent of economic damage attributable to the birds.

The fact that the individuals of all species are not distributed randomly within the roost points to the need for extensive sampling to determine the species composition of the flock. Also, if control is deemed necessary, this clumped dispersion of species within the flock allows the possibility of controlling primarily those species responsible for the most extensive damage. In our samples, Starlings and Grackles made up 98% of the birds in the interior part of homogeneous pine stands. If control measures were confined to these areas, Redwings, Cowbirds, and Rusty Blackbirds, which seem to roost at the margins of pine stands, would not be so severely affected. Since Grackles consume the preponderance of corn, and Starlings of wheat, that is eaten by birds, such a control practice may be just as effective and not as deleterious as extermination of an entire roost.

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TABLE 1. Flock composition estimates for the Fort Campbell, KY Blackbird roost.

Date	Method	Sampler	Sample Size	% Composition by Species				
				Redwing	Grackle	Cowbird	Starling	Rusty Blackbird
14 Dec 74	shotgun	Army	110	18.2	49.1	12.7	20.0	0.0
9 Jan 75	shotgun	Army	150	12.7	56.0	2.0	29.3	0.0
18 Jan 75	shotgun	Authors	112	36.6	26.8	19.6	15.2	1.8
19 Jan 75	shotgun	Authors	273	11.4	47.3	5.9	26.4	9.2
19 Jan 75	strip counts	Authors	1112	3.2	37.5	2.3	55.8	1.2
19 Jan 75	road counts	Authors	2548	9.9	9.3	0.8	80.0	0.0

TABLE 2. Species Composition in strip counts of dead birds.

Class	Number	% Composition				
		Redwing	Grackle	Cowbird	Starling	Rusty
1	112	18.0	54.5	4.5	22.3	0.0
2	262	1.5	52.3	0.8	44.3	1.1
3	600	1.3	30.0	2.8	63.6	1.5
4	138	2.2	24.6	1.4	71.0	0.7

Class descriptions:

1. Badly decomposed but recognizable to species
2. Moderately decomposed; corpse intact
3. Early stages of decomposition
4. Died recently; no decomposition

TABLE 3. Flock composition in different roost areas.

Species	% Composition by Location			
	Deciduous		Pine	
	Interior	Marginal	Interior	Marginal
Redwing	15.0	8.7	1.4	15.6
Grackle	48.0	17.4	63.4	44.2
Cowbird	4.0	47.8	0.0	2.6
Starling	24.0	17.4	35.2	24.0
Rusty	8.0	8.7	0.0	13.6
No. of shots	2	1	4	7
Birds/shot	12.5	5.6	17.8	22.0

TABLE 4. Stomach contents of birds taken from Fort Campbell Blackbird roost 18 and 19 of January, 1975.

Species	Sex	Sample Size (n)	Grams per individual						
			Corn	Wheat	Oats	Weed	Animal	Driden	Total
Starling		60	.07	.02	.00	.06	.35	.15	.66
Rusty		23	.03	--	--	.03	.04	.23	.33
Redwing	F	6	.03	--	--	.30	.05	.27	.69
Redwing	M	60	.16	.01	--	.50	.06	.13	.86
Grackle	F	42	.78	--	--	.09	.26	.16	1.12
Grackle	M	117	1.35	.00	--	.11	.11	.22	1.79
Cowbird	F	13	.15	--	.0[illegible]	.36	.03	.07	.62
Cowbird	M	18	.1[illegible]	--	--	.68	.06	.08	.92
ALL SPECIES		377*	.57	.01	--	.20	.13	.17	1.00
Percent			52.68	0.01	--	18.47	12.12	16.71	99.39
			52.69%			30.59%			

*8 birds were kept intact for use as specimens in other studies. Hence, of 385 birds total, stomachs were analyzed in 377.

TABLE 5. Importance (% Species Composition) of weed seeds in the diet of various blackbird species. Only seeds comprising > 1% of diet are considered.

Weed Species	Common Name	Redwing	Grackle	Starling	Cowbird	Rusty
Polygonum [illegible]	Smartweed	33.4	5.1	1.2	16.1	13.3
Sorghum halepense	Johnson grass	29.3	13.3	---	37.1	3.8
Ambrosia artemisiifolia	Ragweed	13.0	65.6	---	6.8	19.6
Setaria sp.	Foxtail	8.1	10.4	---	5.9	3.9
Digitaria sp.	Crabgrass	6.9	3.8	4.6	8.1	36.3
Amaranthus [illegible]	Pigweed	2.9	---	1.3	1.5	---
Chenopodium album	Lambs quarters	2.9	---	1.5	1.5	---
Zea sp.	Corn	---	---	88.8	---	---
Avena sativa	Oats (wild?)	---	---	91.2	---	---
Lolium sp.	Fescue	---	---	1.2	---	---
Celtis sp.	Hackberry	---	1.3	---	---	---
Digitaria [illegible]	Crabgrass	---	---	---	16.6	27.4
Panicum dichotomiflorum	Fall panicum	---	---	---	3.8	---
Paspalum dilatatum	Tall paspalum	---	---	---	2.3	---

TABLE 6. Identifiable animal species found in stomach analysis of Grackles, Cowbirds, Redwings, Rusty Blackbirds, and Starlings Fort Campbell, Kentucky 18 and 19 January, 1975.

I. Insecta:		
A. Coleoptera		
1. Scarabaeidae	(scarab beetles)	misc. some pests of agriculture
1 sp		
2. Cantharidae	(soldier beetles)	predaceous
1 sp		
3. Carabidae	(ground beetles)	predaceous
Agonum rufipes		+ 1 ? sp.
Acupalpus partiarius (Say)		
Amphasia sp.		
4. Alticinae	(flea beetle)	herbivorous
2 sp.		
5. Staphylinidae	(rove beetles)	predaceous
6. Misc. species		
Aphodius [illegible] (Say)	(or dorsalis)	
Myochrous denticollis		
Ataenius sp.		
[illegible] (Say)		
Diabrotica undecimpunctata howardi (Barber)		
[illegible] sp.		
[illegible] *laevis* (LeConte)		
[illegible] sp.		
[illegible] sp.		
B. Hymenoptera		
1. Formicidae	(ants)	
Myrmica lobicornis fracticornis (Emery)		
Crematogaster cerasi (Fitch)		
C. Diptera		
1. Anisopodidae	(wood gnats)	
Sylvicola sp.		
2. Tephritidae	(fruit flies)	
1 sp		
3. Sphaeroceridae	(dung flies)	
Copromyza sp.		
4. Chironomidae	(midges)	
Smittia sp.		
D. Hemiptera		
1. Nabidae	(damsel bugs)	predaceous
Nabis sp.		
E. Homoptera		
1. Membracidae	(tree hoppers)	minor economic imp't
Stictocephala [illegible]		
2. Cicadellidae	(leaf hoppers)	damage plants
Agallia sp.		
Aceratagallia sp.		
3. Aphididae	(aphids)	serious pests
1 sp		
Rhopalosiphum sp.		
F. Lepidoptera		
1. Noctuidae		
1 sp (pupa)		
Pseudaletia unipuncta		
2. Gelechiidae	(many serious pests)	
1 sp (pupa)		
3. Pyraustinae --	includes European cornborer	
1 sp (possibly *Loxostege* sp)	garden web worm	
II. Chilopoda	Centipedes	
2 sp		
III. Arancida	(spiders)	
Lycosidae	(wolf spiders or ground spiders)	
Pardosa sp.		
IV. Gastropoda	(snails)	
2 sp		

TABLE 7. Other Bird Species Sighted in the Roost Area
(<200 m from main roost)

1.	Red-tailed Hawk	(12)
2.	Great Horned Owl	(1)
3.	Meadowlark	(6)
4.	Bobwhite Quail	(12)
5.	Mourning Dove	(6)
6.	Carolina Chickadee	(abundant)
7.	Song Sparrow	(abundant)
8.	White-crowned Sparrow	(abundant)
9.	Rufous-sided Towhee	(12)
10.	Cardinal	(60)
11.	White-throated Sparrow	(abundant)
12.	Savannah Sparrow	(6)
13.	Downy Woodpecker	(2)
14.	Flicker	(1)
15.	Chipping Sparrow	(6)
16.	Tree Sparrow	(abundant)
17.	Crow	(abundant)

FIGURE 1.
Location and Species Composition of Blackbird Roost Shoots Fort Campbell, Ky.