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IMPACT OF ROOST CONTROL ON LOCAL URBAN AND AGRICULTURAL BLACKBIRD PROBLEMS

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Residents of the southeastern United States have long been concerned about the large winter blackbird (common grackles [*Quiscalus quiscula*], red-winged blackbirds [*Agelaius phoeniceus*], brown-headed cowbirds [*Molothrus ater*])/starling (*Sturnus vulgaris*) roosts that occur there (Graham 1976). Roosts in urban/suburban situations cause substantial nuisance problems (Bliese 1959, Meanley 1975, Garner 1978, Heisterberg et al. 1984*a*). When recurring in specific sites over several years, such roosts are histoplasmosis threats in many Kentucky and Tennessee communities (Chick et al. 1980, Latham et al. 1980). Roost dispersal and habitat manipulation techniques are effective when diligently applied (Mott 1980), but at times they merely result in the birds being driven from 1 undesirable location to another. In these situations, lethal control of the local population at the roost site has occasionally been used. However, little is known of what, if any, advantages lethal control might have for alleviating urban roost problems.

Agricultural damage can also be associated with urban winter roosts. The primary damage is caused by birds foraging at livestock feeding operations (i.e., feedlots) (White et al. 1985). In addition to consuming feed, birds serve as possible vectors of livestock disease (Gough and Beyer 1982). Glahn and Otis (1986) found that bird damage at feedlots was associated with the proximity of feedlots to winter roosts, and suggested that selective control of roosting populations in these areas could help reduce damage. However, White et al. (1985) reported that lethal control at a winter roost site in Tennessee resulted in only temporary reduction in nearby feedlot damage and suggested that the strategy of reducing roosting populations to relieve agricultural conflicts should be reassessed.

Since 1974 aerial application of the surfactant PA-14 (Lefebvre and Seubert 1970) has

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been available for lethal control of wintering blackbird and starling populations. However, aerial application of the chemical has had limited use and mixed results (Garner 1978, Heisterberg et al. 1987) because the proper weather conditions for the effective use of PA-14 when aerially applied occur infrequently (temperatures <7 C accompanied by >1.3 cm of rain [Heisterberg et al. 1987]) and are difficult to predict. Further, the safety hazards associated with aerial application generally preclude treatment of many urban roosts.

In response to the need for better roost control methods, we developed a ground-based multisprinkler spray system (Stickley et al. 1986) followed by a more efficient water cannon device (Heisterberg and Stickley 1988) for applying surfactants to roost sites, without the need for rainfall. Development of these techniques prompted an increase in the use of surfactant roost treatments in Kentucky, Tennessee, and Alabama.

This paper assesses the impact of urban roost treatments using ground-based sprinkler systems in the above states from the winter of 1982–1983 through the winter of 1986–1987. We examine the impact of roost spraying on subsequent winter roosting blackbird and starling populations in the treated communities. We also examine the impact that roost spraying of surfactants (all PA-14 applications with the exception of 1 treatment of the experimental surfactant DRC-6749 [Lefebvre et al. 1987]) had on associated blackbird and starling foraging populations at livestock feedlots and other habitats surrounding these roosts.

METHODS

Roosting Populations

We selected urban roosts for treatment (i.e., within or adjacent to the city limits of smaller [<60,000 people] communities) that were considered to be a chronic nuisance, to cause health problems, or both (Table 1). Roost treatments in 2 larger cities (Huntsville and Memphis) were excluded from this study because they had multiple roosts scattered over large areas to the extent that treatment of 1 or 2 roosts did not have much impact on overall roosting populations in these cities during the winter of treatment. All roost sites were small enough (<5 ha) to allow over half of the birds to be treated. We estimated pretreatment roost populations the evening of treatment using block-counting procedures (Meanley 1965). At the same time the observer(s) randomly identified several hundred individual birds in flightlines to estimate the species composition of the population (Dolbeer et al. 1978). Roost treatment was as described by Stickley et al. (1986) and Heisterberg and Stickley (1988). We estimated the numbers of surviving birds exiting the roost the next morning using the pretreatment procedures. We continued to estimate roosting populations at the treated sites and other sites within the community periodically during the winter of treatment until migration began. We determined numbers of birds killed by counting all carcasses, by species, found in randomly selected 1-m^2 plots and extrapolating this count to the total treated area. The number of plots needed to estimate the kill within ±33% was determined from the variance derived from an initial set of 25 randomly selected 1-m^2 plots (Stickley et al. 1986). Between 27 and 213 ($\bar{x}$ = 66) such plots were required.

To determine if lethal roost control in a community-winter (1 community monitored for roosts for 1 winter) had any influence on roosts forming in that community the following winter, roost populations were monitored the winter after treatment in 9 treated community-winters (6 communities studied for 1 winter each and 1 community studied for 3 winters) (Table 1) and for comparison in 20 "reference" community-winters (2 consecutive winters in communities that had known roost populations at least the first winter and the status known the second winter but had not had spray treatments the 2 prior winters). These included 5 community-winters in Bowling Green, Kentucky; 4 community-winters in Jackson, Tennessee; 4 community-winters in Somerset, Kentucky; and individual community-winters from Munfordville and Russellville, Kentucky and from Fayetteville, Hendersonville, McMinnville, Paris, and Shelbyville, Tennessee.

Fisher's exact test and Chi-square analysis were used to compare the presence or absence of winter roosts subsequent to treatment in the treated communities and subsequent to the first winters of observation in the reference communities. We first tested for treatment effect using data for the first community-winter for a community (n = 7 and 11 for treated and reference communities, respectively). We next tested for all community-winters with the assumption that the presence of roosts in a community in a given winter was independent of roost presence in other years.

Foraging Populations

Six foraging population studies were conducted in conjunction with urban roost sprays. Three treatments, 1 each, in Somerset (Pulaski County), Kentucky; Scotts-

Table 1. Effects of surfactant spray treatments on blackbird/starling roosting populations during community-winters[a] in Alabama, Kentucky, and Tennessee, 1982–1987 (all were PA-14 treatments except for London, Kentucky where DRC-6749 was used).

Community-winters	Estimated roost population	Population killed Total	Population killed %	Populations subsequent winter	Action on habitat	Roost treatment dates
Winter 1982–1983						
Manchester, Tenn.	399,000[b]	323,000	81	<50,000[c]	Thinned	10 and 21 Jan
Lawrenceburg, Tenn.	885,000[b]	464,000	52	<50,000[c]	Bulldozed	9 and 18 Feb
Winter 1983–1984						
Russellville, Ky.	1,367,000[b]	1,311,000	96	<50,000[c]	None[d] Bulldozed[d]	9, 29 Jan and 12 Mar
Somerset, Ky.	499,000[b]	382,000	77	541,000	Thinned	19, 23 Feb
Winter 1984–1985						
Somerset, Ky.	541,000	127,000	23	591,000	None	30 Jan
Scottsboro, Ala.	628,000	408,000	65	1,000,000	None	19 Feb
Winter 1985–1986						
Somerset, Ky.	591,000	516,000	87	150,000	Bulldozed	16 Jan
London, Ky.	103,000	63,000	61	<50,000[c]	None	21 Feb
Winter 1986–1987						
Cave City, Ky.	467,000	184,000	39	<50,000[c]	None	29 Jan

[a] One community monitored for roosts for 1 winter. Some communities were monitored more than 1 winter.
[b] This is the minimal population for the multiple roosts in a community.
[c] Often there may be small assemblages of roosting blackbirds and starlings in communities. These groups are usually not considered major nuisance and health problems.
[d] The site treated on 9 and 29 January was not disturbed; the site treated on 12 March was bulldozed.

boro (Jackson County), Alabama; and London (Laurel County), Kentucky during treatment years 1983–1984, 1984–1985, and 1985–1986, respectively, were monitored only 1–2 weeks post-treatment due to treatments occurring late in the roosting season (mid-February) of each year. Three longer-term studies in Russellville (Logan County), Somerset (Pulaski County), and Cave City (Barren County), Kentucky were monitored at least 1 month post-treatment following roost treatments in January during the winters of 1983–1984, 1985–1986, and 1986–1987, respectively. With the exception of the Logan County study, roosts were selected for treatment if they were separated from other known roosts by at least 50 km. The Logan County roost was 30 km from a major (> 1 million) bird roost in Franklin, Kentucky.

Studies of blackbird and starling foraging populations at each study site were focused within the expected foraging radius (34 km) of birds from the treated roost (White et al. 1985, Glahn and Otis 1986). Feedlots consisting of swine, dairy, and beef cattle operations were located with the assistance of the county extension agent and by driving county roads in the study area. Only feedlots with a past history of bird damage problems, the presence of birds on initial inspections, or the potential for bird problems based on the availability of feeds attractive to birds were sampled, because others were not expected to receive bird use (Glahn and Otis 1986).

Based on the geographical distribution of feedlots to be sampled, a route along county roads connecting these operations was mapped. Each route included from 19 to 22 feedlots except for the Laurel County route, which contained 9 feedlots. With the exception of Laurel County, these routes ranged from 100 to 250 km in length and were centered in the most intensive agricultural areas of the county. In Laurel County the route only extended approximately 13 km east of the roost and was insufficient for conducting roadside surveys. All other routes were used to survey areas between 2 and 34 km from the roost. In all cases the orientation of survey routes and livestock operations was such to survey foraging populations likely to be associated with treated roosts. To help confirm this, birds at selected feedlots in each study area were followed to roosting sites in the evening and the perimeter of each study area driven in the evening to look for flightlines leaving the study area to other roosts.

With the exception of Pulaski 1984, blackbird and starling populations were surveyed along these routes and at feedlots 1–3 times per week for a minimum of 2 weeks before treatment and in the same manner 1–4 weeks post-treatment until the first week of March. This end point was selected so that spring migration would not be a confounding factor. By necessity the Pulaski 1984 study, starting in mid-February, was condensed and consisted of daily surveys for 4 days before treatment and similarly intensive surveys after each of

2 treatments. Each route was driven at 34–50 km/hour traversing the same path each time, and each survey route was scheduled to be completed during the same time interval of daylight (approximately 0800–1400 hrs). Based on past studies (Glahn and Otis 1986), the procedure of surveying feedlots at about the same time each day was chosen to provide the most consistent bird activity patterns over time. The size and species composition of blackbird and starling flocks occurring within 100 m of either side of the road in all habitats and in flight were visually estimated. The observer stopped at each feedlot along the route in sequential order and estimated the size and species composition of blackbird flocks within a 100-m radius of the feedlot feed site. Distances were initially determined with a range-finding instrument and later visually estimated. Size and species composition of flocks utilizing the feed site were also estimated by observing birds feeding, by flushing them from feeders and troughs so that they could be counted and identified, or both. Temperature and presence of precipitation and snow cover were recorded at the start and the completion of each survey route.

In conjunction with the Barren County study, a reference route in Warren County, Kentucky consisting of 9 feedlots in proximity to an untreated roost 50 km southwest of Cave City was monitored. These lots were surveyed 1–2 times a week to help evaluate whether change in poulations of foraging birds in Barren County were indeed treatment-related. We attempted to locate other reference sites, but were unable to do so because of other operational control efforts at roosts or feedlots.

Also in conjunction with the Barren County study, 19 starlings were captured at 3 feedlots 5, 13, and 18 km from the Cave City roost and equipped with radio transmitters 2 weeks before the proposed roost treatment. The 164-MHz transmitters (Kolz and Corner 1975) were attached to the base of the tail with hot melt glue (Bruggers et al. 1983). Transmitters weighed an average of 3.1 g (about 3.5% of the weight of the average 88.5 g starling) and had an expected battery life of 2 to 3 weeks. Two vehicles equipped with 12-channel AVM model LA-12 battery-operated receivers (AVM Instrument Co., Champaign, Illinois) and double yagi antennas were used to monitor transmitter-equipped starlings that were using the Barren County study area and the Cave City roost. This was accomplished by locating daily in the study area as many transmitter-equipped birds as possible, focusing efforts primarily at feedlots along the survey route and at the Cave City roost at night. We defined the tracking period as the number of consecutive nights a bird was known to be in the study area, beginning the second night after transmitter attachment and ending with the last radio contact (Heisterberg et al. 1984*b*). Thus, we assumed birds changed roosts if they remained in the study area but did not return to the Cave City roost. If the last radio contact within the study area occurred prematurely, it was assumed that either the transmitter had failed (several were known to have failed) or that the bird in question had left the study area. Telemetry data were analyzed (Heisterberg et al. 1984*b*) to examine nightly turnover and fidelity of starlings in the study area to the treated roost site during the tracking period defined immediately before treatment. Because of a delay in the roost treatment, radio contact was lost with most birds before treatment.

Data from roadside and feedlot flock counts were analyzed separately for each treated and reference site. These data were summarized into totals of blackbirds and starlings seen during roadside censuses and mean birds per feedlot surveyed. These data were ranked across pretreatment and post-treatment periods. A Mann-Whitney *U*-test (Hollander and Wolfe 1973) was used to compare differences between periods. Similarly, we analyzed weather data including mean temperature and snow cover occurrence between periods.

RESULTS AND DISCUSSION

Impact on Urban Bird Problems

Almost immediately following roost treatments, blackbirds and starlings (survivors or recruits to the treated roosting populations) generally avoided roosting in the specific sites or portions of sites that had been treated. At 3 sites, Lawrenceburg, Tennessee, Scottsboro, Alabama, and London, Kentucky, birds abandoned the site altogether. Exceptions to this avoidance reaction were the treated roosts in Manchester, Tennessee, Russellville, Kentucky, and Cave City, Kentucky, where birds from outside the treated population invaded the site. The Manchester roost was located directly under an established flightline to a much larger roost 25 km away. Birds continued to drop out of this evening flightline to roost in the treated site. They continued to roost there until all ground vegetation was removed and the trees had been substantially thinned. In Russellville, also located close to another major roost (see below), birds continued to roost in the area treated on 9 January until it was retreated on 29 January. After this treatment birds moved to a different site 1 km to the east that was treated on 12 March and then bulldozed (see Table 1). At Cave City the remnant population shifted, for the most part, into similar habitat contiguous to the treated area. The roost increased to almost 700,000 birds within a week after treatment, and many roosting birds spilled over into the treated area and remained until March. Except for Manchester, Russellville, and Cave City, post-treatment roost populations within the communities at large were low (<50,000 birds) and were no longer considered a significant urban roost problem.

Spraying a roost in a small to medium-sized community (<60,000 people) 1 winter may reduce the chance of a roost forming the next winter. Considering data using communities only once in consecutive winter roost occurrences, roosts returned to 2 (29%) of 7 treated communities versus 8 (73%) of 11 reference communities. A Fisher's Exact Test indicated a difference ($P = 0.009$) in the probabilities of these occurrences. A difference ($\chi^2 = 5.11$, 1 df, $P = 0.024$) in the likelihood of a roost forming the following season was also found between the 9 treated community-winters (Somerset sprayed 3 winters and included 3 times [Table 1]) and the 20 reference community-winters also containing communities used more than 1 year. Roosts returned to 4 (44%) of the 9 treated communities the following winter compared with 17 (85%) of the 20 reference ones. Although varying degrees of habitat alteration at roost sites following sprays in treated communities may have influenced the reformation of roosts in the subsequent winter, this is unlikely because most treated communities had suitable alternative roosting habitat available.

In the 4 treated community-winters (Somerset for 3 winters) in which roosts recurred, the roosts did not reform the following winter at the same sites that had been treated the previous year (the last site treated at Somerset was bulldozed, but similar habitat contiguous to the bulldozed site was not bulldozed and was not occupied later). In the winter of 1985–1986 at Somerset, the birds returned to the same general roost area they had occupied at the end of the previous winter, but they avoided the specific area that had been previously treated. In Scottsboro, the winter after treatment, the roost moved to an industrial site on the edge of town. In contrast, Heisterberg et al. (1984*a*) indicated that 44% of 16 winter roosts in untreated communities reformed in previously occupied roost sites.

In some cases the avoidance of treated roost sites persisted for more than a year. The Russellville site treated in January 1984 was never bulldozed and had not been reoccupied as of 1989. The Somerset site treated in January 1985 but left intact had not been reoccupied as of 1989, nor had the Manchester site, which was treated and thinned in January and February 1983. However, a site in Somerset that was also treated and thinned in February 1984 was again occupied by blackbirds and starlings the winter of 1986–1987.

Disposition of the dead birds following treatment is often a problem for communities (Stickley et al. 1986). Several communities have utilized city workers and prison trustees to pick up the dead birds or rake them into backhoe-dug trenches. However, the easiest and most used disposal method is to bulldoze the treated roost trees and other vegetation including the dead birds into large piles and then burn them (Stickley et al. 1986). These operations could potentially present a human health hazard from the respiratory disease histoplasmosis if the roost soil contains the spores of this fungus (*Histoplasma capsulatum*) (Stickley and Weeks 1985). Workers who might be used to clean up the birds in such a roost would risk contracting the disease, and bulldozing roost soils infected with the fungus could provide a widespread source of human infection to the community from airborne spores (Stickley and Weeks 1985).

Impact on Agricultural Problems

Agricultural damage caused by blackbird/starling roosts has been attributed primarily to starlings (Glahn 1984, White et al. 1985). Starling percentages at roosts with the exception

Table 2. Numbers and percent of starlings among roosting birds and roosting birds killed during 6 roost spray studies following surfactant sprays, and among foraging birds along roadsides, at feedlots, and those using livestock feed before and after treatment (Alabama and Kentucky, 1983–1987).

	Roosting birds				Foraging birds					
	Starlings in roost		Starlings in kill		Roadside starlings		Starlings at feedlots		Starlings using feed	
Roost (county, yr)	Total	%	Total	%	pre %	post %	pre %	post %	pre %	post %
Russellville, Ky. (Logan, 1983–1984)	191,300[a]	12	196,800[a]	18	9.1	3.0	64.3	55.8	81.5	77.6
Somerset, Ky. (Pulaski, 1983–1984)	76,500	15	69,700	18			39.2	61.0	50.2	63.5
Scottsboro, Ala. (Jackson, 1984–1985)	6,280[a]	1	20,400[a]	5	4.4	11.1	5.0	6.0	34.1	5.5
Somerset, Ky. (Pulaski, 1985–1986)	29,550	5	25,800	5	13.9	82.4	93.6	100	88.4	100
London, Ky. (Laurel, 1985–1986)	25,750	25	17,000	27	5.6	100	87.3	11.7	100	100
Cave City, Ky. (Barren, 1986–1987)	196,140	42	75,010	41	52.9	38.6	90.9	91.9	99.6	89.5

[a] Larger numbers of starlings killed than starling totals in the roost are a result of sampling errors in estimating roosting species composition, sampling errors in estimating the roost kill, or both.

of Cave City ranged from 1 to 25% (Table 2). Starling composition in the Cave City (Barren County) roost was estimated at 42%. Starlings composed between 4.4% and 13.9% of birds on pretreatment roadside counts except in Barren County where they composed 52.9% of the birds. However, with the exception of Jackson County, starlings ranged from 39 to 94% of birds at feedlots before treatment (Table 2). In Jackson County red-winged blackbirds and brown-headed cowbirds were the predominant species both at the roost and in feedlots. Starlings represented 50 to 100% of birds observed consuming livestock feed at feedlots other than those in Jackson County. Starlings represented 34% of birds consuming feed in Jackson County despite composing only 5% of the bird flocks at feedlots (Table 2). These data confirm previous findings (Glahn 1984) that starlings are the primary species of concern in feedlot losses and suggest that control operations directed at restricting this damage must adequately reduce the starling component of these roosts. Although previous data (White et al. 1985) have suggested that starlings are resistant to PA-14 aerial treatments, a paired t-test analysis of pretreatment starling composition with starling composition of the kill at 6 roost spray studies (Table 2) indicated no difference ($t = -2.21$, $P = 0.078$). Probably due to sampling errors, 4 of 6 kills actually had numerically higher percentages of starlings in the kill than in the roost. These data suggest that starlings are killed with ground-based PA-14 treatments approximately proportional to their composition in the roost.

Blackbird and starling populations censused during feedlot surveys indicated an initial reduction of birds for 1–2 weeks following the PA-14 treatments in Jackson County and Pulaski County 1983–1984, and the DRC-6749 treatment in Laurel County (Fig. 1). Although pretreatment data were highly variable, counts on the day of the treatment were close to the mean of other pretreatment days and were followed by pronounced declines. However, numbers of birds in Laurel County feedlots rebounded after 1 week post-treatment, and post-treatment counts did not differ from pretreatment levels ($U = 41, 50$; $n = 6, 7$; $P = 0.940$). These findings may have resulted from survivors of the roost spray forming a small

(<50,000 bird) roost within 2 km of the treated site after treatment. Although birds in feedlots at Jackson and Pulaski counties were reduced 80–83% up to 10 days post-treatment (U = 118, 128; n = 11, 5; P = 0.007; U = 38, 28; n = 4, 7; P = 0.011), increases in post-treatment temperatures (U = 66, 70; n = 11, 5; P = 0.002; U = 37, 29; n = 4, 7; P = 0.018) may have influenced these reductions. Bird populations from roadside surveys were also reduced (U = 137, 16; n = 12, 5; P = 0.003; U = 38, 28; n = 4, 7; P = 0.007) in the Jackson and Pulaski 1984 study areas (Fig. 2). Data from our 6 study sites including those from longer-term studies (below) support the findings of White et al. (1985) that foraging populations are likely to be reduced for 1–2 weeks following surfactant treatments. That short-term declines in feedlot populations were treatment-related can be partly supported for Pulaski in 1984, because declines at this site occurred at the same time that bird numbers remained high at feedlots associated with the Logan roost (Fig. 3). Although in most cases our study design does not permit statistical inference of treatment-related declines in bird numbers, we believe that the consistent bird population declines or low counts immediately after treatment at study sites overall are unlikely to be due to other factors or to chance alone. It is not clear whether more sustained reductions at Pulaski 1984 and Jackson counties would have occurred if spray treatments had been conducted earlier in the winter.

Longer-term studies (1 month post-treatment) in Logan, Pulaski (1985–1986), and Barren counties allowed assessment of whether sustained population reduction would occur after treatment. All showed an initial reduction of birds in feedlots and along roadsides for 1–2 weeks post-treatment (Figs. 3 and 4). However, in Logan County bird populations along roadsides and at feedlots rebounded rapidly, despite 2 treatments of the same roost site 20 days apart. Overall, roadside populations showed no reduction post-treatment (U = 49,

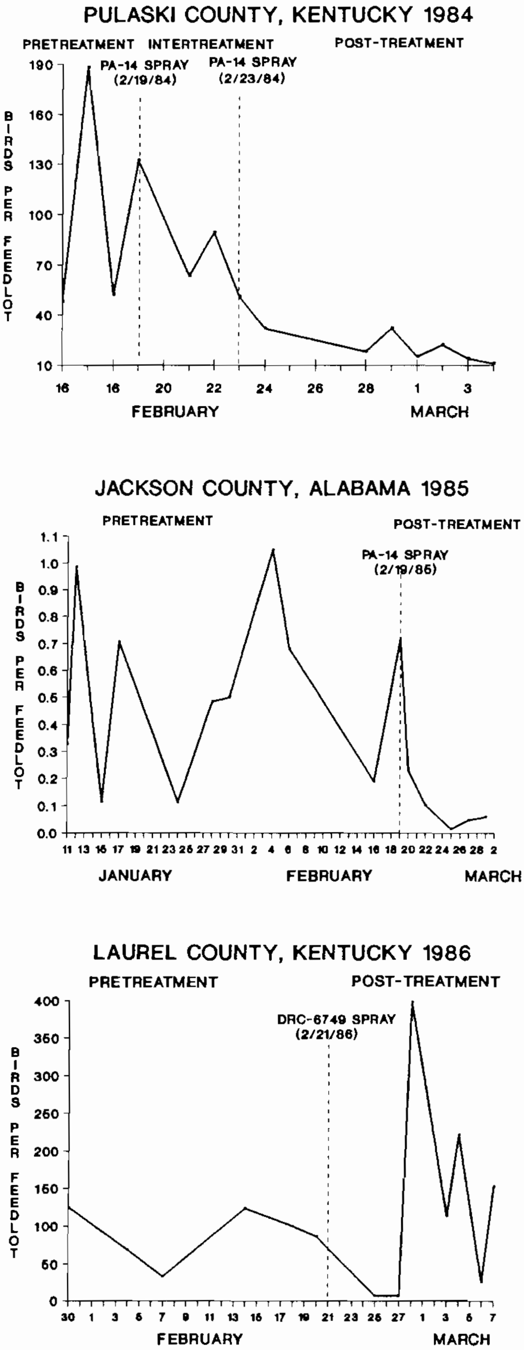

Fig. 1. Trends in blackbird and starling flock counts at feedlots before (pretreatment) and for 1 to 2 weeks after (post-treatment) surfactant roost sprays at 3 study sites.

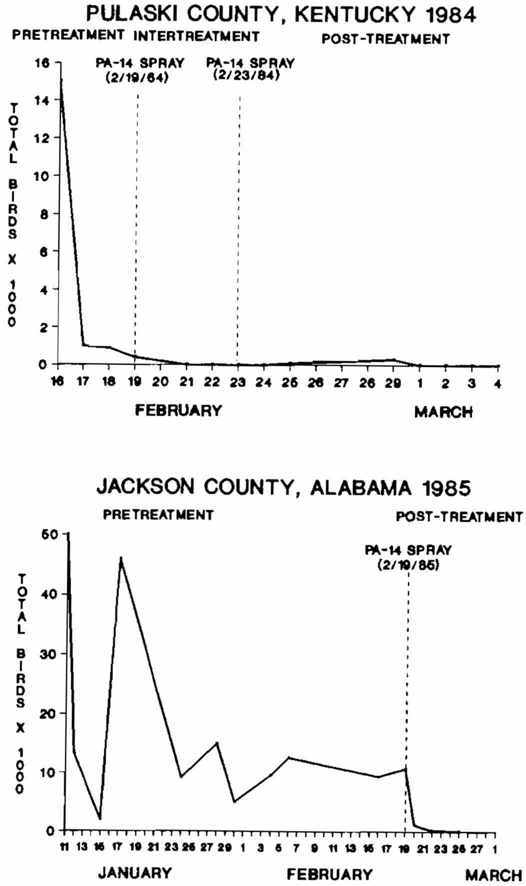

Fig. 2. Trends in roadside flock counts of blackbirds and starlings before (pretreatment) and for 1 to 2 weeks after (post-treatment) surfactant roost sprays at 2 study sites.

42; $n = 8, 5$; $P = 341$) and feedlot populations increased ($U = 43, 62$; $n = 8, 6$; $P = 0.033$). Evening flightlines leaving the Logan study area after the first treatment were tracked to a roost at Franklin, Kentucky 30 km southwest of Russellville, and birds from this roost conspicuously interchanged with the surviving population from the Russellville roost. These data paralleled those of White et al. (1985) after a roost treatment in Milan, Tennessee. In that study birds from roosts in proximity to the treated roost also filled the void left in feedlot habitat by birds killed in the roost treatment.

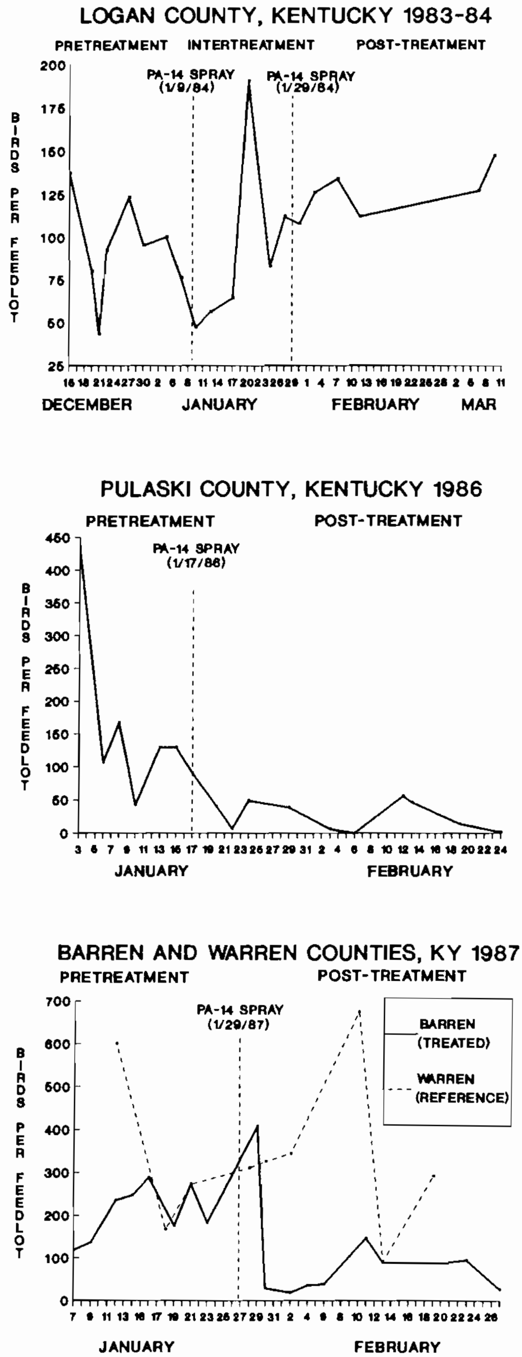

Fig. 3. Trends in blackbird and starling flock counts at feedlots before (pretreatment) and for approximately 1 month after (post-treatment) surfactant roost sprays at 3 treated study areas and 1 reference area.

In contrast to the Logan County study, those in Pulaski (1986) and Barren counties with isolated roosts (those separated from other roosts by at least 50 km) showed a reduction in birds at feedlots (U = 95, 58; n = 7, 10; P = 0.002; U = 133, 57; n = 9, 10; P < 0.001) up to 1 month following treatments (Fig. 3). No weather differences (U = 55, 98; n = 7, 10; P = 0.464; U = 76, 114; n = 9, 10; P = 0.265) pretreatment versus post-treatment were observed during the Pulaski or Barren County study, suggesting that weather was not responsible for the observed reductions. A lack of difference (U = 18, 27; n = 4, 5; P = 0.713) in pretreatment and post-treatment bird populations at feedlots at the reference route in Warren County suggested that the reduction in Barren County was treatment-related (Fig. 3). However, a steady decline of pretreatment feedlot populations at the Pulaski (1986) site confounds the determination of whether post-treatment reductions were treatment-related. Although the timing of the Laurel study in the same year did not permit direct comparison, it did confirm that reductions were not due to region-wide early migration. Studies in Logan County in 1984 and Warren 1987 suggested increases in feedlot populations in late January and February. Also, previous studies in Tennessee (Dolbeer et al. 1978, White et al. 1985) indicated a steady increase in feedlot populations from the period of December through the end of February. Thus, sustained reductions of birds at feedlots during the Pulaski County study were probably treatment-related.

Following the successful (87% reduction) roost treatment in Pulaski County in 1986, roadside populations were reduced (U = 92, 61; n = 7, 10; P = 0.005) by 93% (Fig. 4). In Barren County, however, there was only a 39% reduction in the roosting population immediately after treatment and roost populations exceeded pretreatment after 1 week. In response to this, roadside populations of starlings and blackbirds initially declined by 63% and 35%,

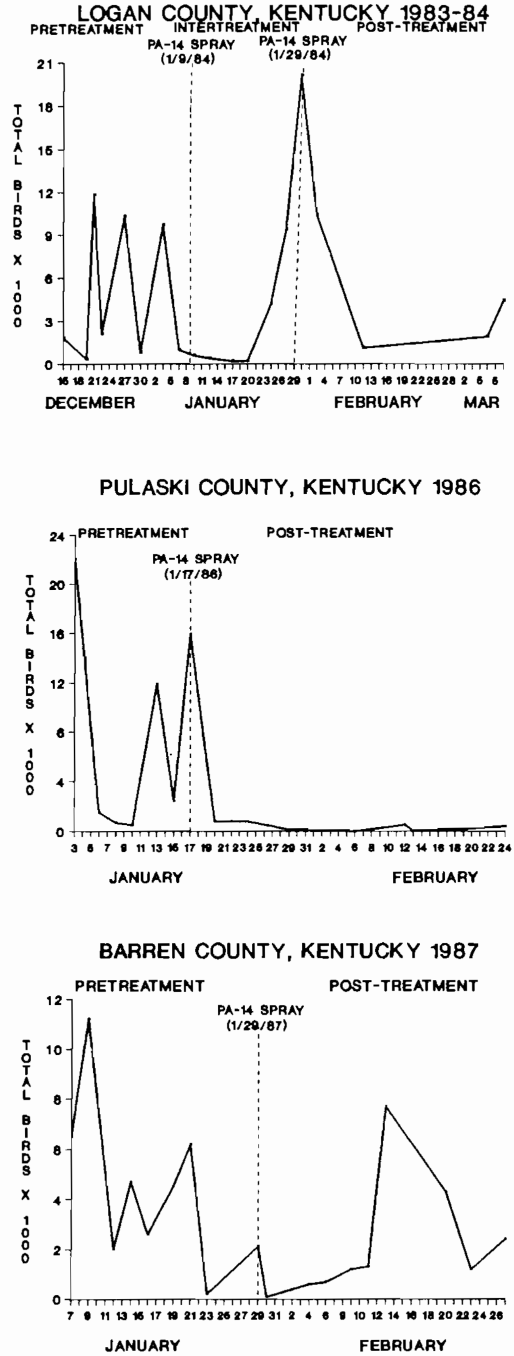

Fig. 4. Trends in roadside flock counts of blackbirds and starlings before (pretreatment) and for approximately 1 month after (post-treatment) surfactant roost sprays at 3 study sites.

respectively, but were not different (U = 114, 76; n = 9, 10; P = 0.055) from pretreatment numbers (Fig. 4). Whether post-treatment roadside population responses were treatment-related is difficult to ascertain because counts were highly variable pretreatment and in 3 cases were declining immediately before treatment (Figs. 2 and 4). We believe they were in part treatment-related, because in all cases they paralleled post-treatment population trends at or near the treated roost site.

Starling fidelity to the treated roost contributed to population reductions at feedlots following roost treatment. Of 19 starlings equipped with transmitters at feedlots 5 to 18 km from the roost, 5 were lost before the start of the tracking period. Of 14 starlings tracked at least 2 nights after the night following release (a total of 68 tracking nights), birds used the Cave City roost on 63 tracking nights for an average roost fidelity of 92.6%. Nightly starling turnover at the Cave City roost was calculated at only 9.2%. The lack of reinvasion of feedlots in Barren and Pulaski counties can probably be attributed to the high fidelity of starlings to the treated roost and lack of sufficient nearby starling populations to repopulate these study areas. However, it is clear from previous studies (Heisterberg et al. 1984*b*, White et al. 1985) that high fidelity to specific roost sites may be atypical.

Ten out of 14 birds used the Cave City roost on all nights tracked. The other 4 birds spent 4 of the 5 tracking nights in barns at feedlots in the study area. One or more barn roosts of starlings were located in all study areas except in Laurel and Jackson counties and may constitute a source of feedlot starling populations unaffected by surfactant spray treatments of roosts.

MANAGEMENT IMPLICATIONS

In most cases, successful roost treatments (those resulting in the deaths of more than half the roosting birds) generally eliminate or reduce the nuisance of roosting birds in the immediate area of the roost treatment site and community at large for the rest of the roosting season. Avoidance of the treated site appears to persist through the subsequent winter and possibly longer. In general, smaller communities (i.e., those containing less than 60,000 people) are less likely to have a roost the winter following roost treatment than similar communities without these treatments. However, this may not be true in larger communities where there may be a greater chance for a roost to form elsewhere in the community the following winter.

Roost management with respect to the histoplasmosis fungus indicates that roosts occupied by birds 3 years or more are likely to harbor the fungus and should not be disturbed (Stickley and Weeks 1985). Surfactant treatment can be used at a roost site that has been occupied by birds for less than 3 winters because there is less danger that the area is contaminated with this fungus. In fact, treatment of the birds in a site occupied 2 years or less may help ensure that the site stays free of histoplasmosis because birds generally avoid roosting in a site that has been treated. However, if a particular roost site has been occupied by birds for 3 years or longer, prudence would dictate dispersal of the roosting birds to another site rather than surfactant treatment because dead bird removal following surfactant treatment would probably involve disturbance of the soil and potential hazards to humans from dissemination of fungus spores.

In certain situations, treatments of winter roosting sites can be effective in reducing blackbird/starling populations in agricultural areas. However, predicting the effectiveness of these treatments could be difficult because it is related to roosting dynamics at the target roost as well as at other known and unknown roosts in the area. Based on our results, control of feedlot bird populations by means of surfactant roost treatments is most likely to occur when the treated roost is isolated from other roosts by at least 50 km and contains a high percentage of starlings. Because we purposely selected 5 of 6 study areas based on geographic isolation, our study favored demonstrating effectiveness and is probably not typical of expected results of roost spray treatments in general. Although ground-based treatments appear to be effective for controlling the starling component of blackbird roosts, they are relatively costly ($670/ha; Heisterberg et al. 1987) for a technique that only reduces depredating bird populations in certain situations. Other methods, such as reducing the use of feed types palatable to birds (Twedt and Glahn 1982), use of toxic baits (Glahn 1982), and livestock feed bird repellents (Mason et al. 1985) are more likely to provide predictable, selective, and more cost-effective control of feedlot damage by starlings in the long-term.

SUMMARY

The impact of ground-based surfactant roost treatments in Kentucky, Tennessee, and Alabama on reducing urban and agricultural blackbird problems was evaluated in 9 roost treatments for urban and 6 roost treatments for agricultural problems. Effectiveness of roost site treatments in resolving urban health and nuisance problems in communities was estimated by examining reoccupation of these specific sites by roosting populations in the treatment winter and subsequent winters. Alleviation of agricultural problems due to treatments was assessed through repeated population surveys of blackbirds and starlings along roadside habitat and at livestock feeding operations (feedlots) before and after roost treatment.

Following roost treatment, birds (survivors or recruits to the treated population) generally avoided roosting in the specific areas that had been treated during the year of treatment and the subsequent winter. However, reoccupation of treated roost sites left intact more than 1 year is more likely, and roosts may recur elsewhere in the communities treated depending on the size of the community and the availability of other suitable roost habitat. There is a better than equal chance (5 of 9) that treating a roost in a small to medium-sized community (<60,000 people) will prevent a roost from forming in that community the following winter compared to the high (85%) percentage of roosts reforming in untreated communities.

Surfactant treatments appeared to be effective in reducing blackbird/starling populations at feedlots in the short-term (1–2 weeks), but were effective at only purposely selected isolated roosts in the long-term (1 month post-treatment). Starlings, the primary damaging species, appeared to be at least equally susceptible to surfactant treatments as other roosting species. The geographic isolation of treated roosts, and fidelity of foraging starlings to that roost appeared to be the primary factors influencing whether roost treatments would be successful for reducing agricultural damage in the long-term.

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