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# Current Status and Potential of Lethal Means of Reducing Bird Damage in Agriculture

**Richard A. Dolbeer**
U.S. Department of Agriculture, 6100 Columbus Avenue, Sandusky, Ohio, U.S.A. 44870

**Abstract**
Various methods are currently used to kill birds that damage agricultural crops. At livestock feedlots, birds are fed toxic baits (U.S.A.), and nearby roosts are sprayed with a surfactant (U.S.A.) or a toxicant (France). In orchards, birds are trapped (U.S.A.), mist-netted (Israel), or poisoned (Calif.), and nearby roosts are dynamited (Belgium). Roosting and nesting Red-billed Queleas in Africa are sprayed with a toxicant to reduce their damage to ripening grain crops. Dynamite, toxic baits and sprays, and shooting are also used in other agricultural situations to reduce depredating populations. Most field evaluations of lethal-control techniques have put far more emphasis on the number of birds killed than on how much damage was eliminated in relation to the cost of control. Developmental and operational costs of lethal-control techniques need to be considered in relation to the extent of damage reduction to ensure that future control programs are cost-effective.

## Introduction

Whenever birds have threatened agricultural crops, the natural response of farmers has been to attempt to reduce the depredating populations. Laws were established as early as 1424 in Europe and 1667 in North America to encourage the killing of Rooks (*Corvus frugilegus*) and blackbirds (Icterinae) to protect grain crops (Wright *et al.* 1980; Dolbeer 1980). During the 19th century, initial attempts to establish laws protecting overexploited species such as the Passenger Pigeon (*Ectopistes migratorius*) were often thwarted by agricultural groups concerned about bird depredations (Schorger 1973).

Killing birds to protect agricultural crops is often viewed negatively today by the general public in developed countries. Many people in these countries are isolated from agriculture and pest control and have little sympathy or understanding for such practices. In addition, research has revealed that agricultural losses to birds are often not as great as initially supposed (e.g., Dyer and Ward 1979; Weatherhead *et al.* 1982) and that many pest species also have attributes beneficial to man (e.g., Stewart 1975; Bendell *et al.* 1981). Finally, because of their beneficial attributes and migratory habits, most bird species in developed countries have achieved some level of legal protection, often at the international level. The status of birds as agricultural pests and the management options available are often different from those for other pests such as rodents, insects, and weeds.

My objective is to review the status of lethal means of reducing bird damage in agriculture. What methods are currently being used to kill birds in agricultural situations? Under what conditions has lethal control been and not been economically justified and effective in reducing damage? Is there economic justification for the development of new methods of lethal control to reduce bird damage?

## Economic Justification for Bird Control

Studies of bird damage to various agricultural crops have established that overall losses on a regional or national level are almost always less than 1% of the total production (e.g., Elliott, in press). Thus, bird damage usually does not have a significant impact on the overall farm economy. If all farmers received losses of less than 1%, there would be little conflict; however, losses are not equally distributed—generally a small percentage of farmers located near concentrations of birds receive significant losses (>5% of crop), whereas the vast majority (>95%) of farmers receive insignificant losses (Dolbeer 1981). Bird-control programs, whether lethal or nonlethal, should be aimed at the relatively few farmers with high losses and not at the entire farming community.

## Lethal Control for Reducing Damage at Feedlots

### Poisoning at Feedlots

The development of intensive rearing facilities where livestock are fed grain and high-protein diets has created bird-depredation problems, especially in winter (Feare 1975). In the early 1960s, several toxicants were evaluated for their effectiveness in reducing bird numbers, primarily European Starlings (*Sturnus vulgaris*), at feedlots in the United States. Elliot (1964) used 7.3 t of thallium sulfate-treated bait during the winter of 1962–63 at eight feedlots in Idaho and Oregon and killed an estimated 1.2 million European Starlings. He stated that "control was obtained at every feedlot where bait was exposed," but no data were presented on costs of baits, material, and labor in relation to damage alleviated. Levingston (1967) killed 400 000 starlings with TEPP-treated baits at a feedlot in northern California during the winter of 1963–64. In two subsequent winters, 3.5–5.0 million starlings were killed after baiting with DRC-1339. Again, no information on cost of baiting in relation to amount of damage alleviated was presented, other than the statement that "effective and economic control was achieved at the feedlot by continuous baiting with DRC-1339."

Besser *et al.* (1967) evaluated DRC-1339 at a cattle feedlot in Nevada by ground-baiting with treated poultry pellets. They estimated a 75% reduction of an initial population of 2200 starlings at the lot over a 7-d period. Royall *et al.* (1967), in a similar study at a turkey farm in Utah, reduced a population of 1800 starlings by 89–93% for 7 d after baiting with DRC-1339-treated pellets. Neither study monitored population trends at the lots beyond 7 d.

DRC-1339 was deemed the most satisfactory of the experimental toxicants because it was highly toxic but slow-acting for starlings, posed minimal secondary hazards, and had low mammalian toxicity (DeCino *et al.* 1966). It was registered in the United States in 1968 as an avian toxicant for use primarily at feedlots and marketed commercially under the name "Starlicide" (M.L. Eschen and E.W. Schafer, Jr., unpublished data).

There have been three evaluations of DRC-1339 baits at feedlots since registration in 1968. Stickley (1979) measured the effect on starling populations from use of DRC-1339 baits for 9–15 d in Tennessee at four feedlots during the winter of 1979. He concluded that "the inconsistent pattern of snow cover . . . precluded determination of the effectiveness of Starlicide baiting. The observed posttreatment bird activity reductions of about 90% may have been caused as much by lack of snow cover as by Starlicide." He also noted that "bait aversion may be a problem in long-term use of Starlicide." Short-term evaluations of DRC-1339 baits at two feedlots each in Kentucky (J.F. Besser and O.E. Bray, unpublished data) and Tennessee (J.F. Glahn and D.E. Steffen, unpublished data) in the preceding two winters were also inconclusive, although in one lot in the latter study a 97% reduction ($P < 0.05$) in starling activity was measured for 3 d after baiting stopped. None of these studies provided cost–benefit evaluations.

Another toxicant (4-aminopyridine [4-AP]) is registered in the United States under the trade name Avitrol for bird control at feedlots (M.L. Eschen and E.W. Schafer, Jr., unpublished data). In theory, 4-AP works as a frightening agent, with the few birds ingesting treated bait repelling flocks from the feedlot. In practice, the product can cause considerable mortality when used around feedlots. J.F. Glahn (unpublished data) evaluated Avitrol bait diluted 1:9 with untreated feed as a frightening agent at an Arkansas feedlot in February 1982. At least 5400 Brown-headed Cowbirds (*Molothrus ater*) and starlings, over half the maximum birds counted in the lot, were killed after 3 d of baiting. Within 8 d, numbers returned to or exceeded pretreatment levels, and Glahn concluded that the effectiveness of this approach in long-term reduction of starling–cowbird problems at feedlots was questionable. The feedlot was 10 km from a roost containing 125 000–250 000 starlings and cowbirds.

Feare *et al.* (1981) attempted to control starlings at a dairy farm in winter with stupefying baits (alpha-chloralose and secobarbital sodium). These drugs were used so that affected nontarget birds could be revived. The authors estimated that about half the original population of 900 starlings was killed over a 3-d period of baiting, but that numbers rapidly returned to pretreatment levels as new birds immigrated to the area. The speed of immigration, together with the effort required to collect stupefied birds, suggested to them that the technique was not satisfactory.

**Roost Control to Reduce Feedlot Damage**

West (1968) attempted to reduce starling damage at feedlots in Colorado in winter by baiting with DRC-1339-treated pellets two areas where the birds assembled before roosting at night. The roost contained a maximum of 250 000 starlings and was within 35 km of 250 cattle feedlots. West baited for 20 d between November 1964 and March 1965 and estimated a 60% population reduction in roosting starlings. Preroosting-area baiting was continued in the next two winters, after which time West *et al.* (1967) concluded "the starling population wintering near Denver has decreased by more than 90%." The actual decline in bird use at feedlots was not determined. Additional preroosting-area baiting trials with DRC-1339 in winter in Tennessee and Kentucky during 1977–78 resulted in kills of up to 100 000 blackbirds and starlings each winter (J.F. Glahn and J.F. Heisterberg, unpublished data; C.E. Knittle *et al.*, unpublished data). Those kills represented less than 10% of nearby roosting populations. Bird use at feedlots in the areas was not monitored.

Another approach to alleviating feedlot depredations by birds in the southern United States, along with localized nuisance and public-health problems, has been to spray winter blackbird and starling roosts with the surfactant, PA-14. Between 1974 (when PA-14 was registered for roost spraying in the United States) and March 1986, about 60 roosts were sprayed and 26 million blackbirds and 7 million starlings killed (Garner 1978; A.R. Stickley, Jr., unpublished data). On only one occasion have bird numbers in feedlots in the area around a roost been monitored before and after a spray operation. White *et al.* (1985) reported 96% of 1.1 million blackbirds and starlings were killed after a roost in Tennessee was sprayed in mid-January 1977 to reduce bird depredations at area feedlots. Numbers of birds at feedlots 20–40 km from the roost declined for about two weeks after the spray, but then increased to above prespray levels until spring migration in March.

In France, experimental aerial applications of toxicants (primarily DRC-1347, the free base of DRC-1339; Schafer *et al.* 1969) have been made on winter roosts of starlings since 1979 to reduce damage in feedlots (unpublished reports, 1979–83, Starling working group, Ministry of Agriculture, France). Relatively large kills have been achieved after some sprays, but the overall effect on starling populations and feedlot damage has not been well documented. For example, in the 1982–83 winter, five roosts were sprayed and up to 600 000 starlings killed. However, farmers reported a significant reduction in starling numbers on their farms after only one of the five sprays. Additional work is needed to document the economic losses caused by starlings, the reduction in starling numbers at farms after spraying, and the environmental effects of spray applications of DRC-1347 at the rate of 66–123 $kg \cdot ha^{-1}$.

## Lethal Control for Reducing Damage to Fruit Crops

In the western United States, decoy trapping in spring and early summer has been employed to remove starlings and House Finches (*Carpodacus mexicanus*), especially juveniles, from fruit-growing areas. Elliot (1964) reported the use of 100 traps in the Yakima Valley, Wash., to kill 110 000 starlings in 1961–63.

He indicated this removal "practically eliminated starling damage to the Yakima Valley cherry crop," although no cost–benefit data were provided. Larsen and Mott (1970) reported that trapping 3500 House Finches in a blueberry planting in Oregon resulted in "considerably less damage," but no supportive data were provided. Palmer (1972), in one of the few studies on lethal control to provide cost–benefit data, indicated that a combination of trapping and poisoning with strychnine-treated baits was cost-effective in reducing finch damage in a fig plantation in California. Plesser *et al.* (1983) used mist nets for 10 d in a 10-ha vineyard in Israel and eliminated about 2700 House Sparrows (*Passer domesticus*) and all bird damage. Damage in the preceding year equaled $4500.

In Belgium, a more radical approach to reduce starling damage to cherries has been the dynamiting of roosts during the cherry-ripening season. From 1972 to 1979, 25 starling roosts were dynamited (2–4 per year) and about 850 000 starlings killed (Tahon 1980; Stevens 1982). The mean annual kill of about 100 000 birds represented less than 20% of the population in the area and had little impact on population levels in subsequent years. The short-term effect on starling damage to cherries was not measured. Each dynamiting operation required at least 200 man–days of labor plus 200–300 kg of dynamite.

In North Africa, millions of European Starlings were killed in the late 1950s to protect olive groves by the application of parathion to winter roosts (Bub 1980). This practice has apparently continued with the substitution of fenthion for the more toxic parathion (Feare 1984). Benefits of this killing in relation to monetary and environmental costs are unknown.

## Lethal Control for Reducing Damage to Grain and Oilseed Crops

The most extensive bird-control program undertaken to date is in Africa, where up to 1 billion Red-billed Queleas (*Quelea quelea*) have been killed annually since the 1950s to reduce damage to ripening grain crops (Ward 1979). The strategy primarily has been to locate and destroy, usually by aerial or ground spraying with fenthion, as many nesting colonies and roosting congregations as possible. Ward (1979) concluded that these control operations, although obviously successful in killing birds, have done little to reduce total population levels of queleas. He advocated a revised policy in which the goal of total population reduction be abandoned in favor of a policy of destroying "only those concentrations . . . existing in, or close to, an important cereal producing area, and confined in time to periods of the year when there are crops at a vulnerable stage." Because queleas annually destroy less than 1% of the total grain crop in Africa (Elliott, in press) and because total population control is prohibitively expensive, Ward's (1979) conclusions appear valid from a cost–benefit perspective. Jaeger and Erickson (1980) applied this strategy in Ethiopia with an apparently favorable benefit-to-cost ratio. They destroyed several large nesting colonies of queleas immediately before the sorghum crop ripened and measured a substantial reduction in damage from that measured in previous years. The key to this strategy is to have sufficient understanding of the movements of queleas to know which colonies or roosts pose a threat to nearby agriculture.

In North America, blackbird damage to ripening corn, rice, and sunflower crops in late summer is a localized but chronic problem. Economically significant damage (>5% of crop) usually occurs within 10 km of late-summer roosts containing up to several million birds. As in Africa, if lethal control is considered for alleviating localized bird damage to these ripening crops, the killing should be directed at those roosting populations directly responsible for the damage. This conclusion is based on the findings that blackbird movements are generally restricted in late summer (Dolbeer 1982) and that killing birds immediately before the damage period results in fewer birds available to damage crops than if the birds were killed at other times of the year (Weatherhead 1981; R.A. Stehn, unpublished data).

Only a few attempts, all unsuccessful, have been made to reduce these late-summer concentrations of depredating birds, either by trapping (Meanley 1971; Weatherhead *et al.* 1980) or by using poisoned baits (Snyder 1961). No attempts have been made to spray contact toxicants or surfactants on late-summer-roosting birds. Although products with low mammalian toxicity, such as fenthion or DRC-1347, would probably be effective, their use has not been pursued. Most late-summer roosts associated with agricultural damage are in marshes containing a diversity of nontarget organisms. Concern over effects on nontargets and introduction of toxic chemicals into aquatic systems have inhibited the pursuit of this management strategy in North America.

The major lethal-control program directed toward blackbirds in North America has been the spraying of winter roosts with PA-14 as described above. Treated roosts are required to be in upland sites containing a few nontarget organisms. Because these roosts are generally far removed from late-summer damage locations, both temporally and spatially, the killing has had insignificant impact on late-summer blackbird populations and damage (Dolbeer *et al.* 1976; Dolbeer and Stehn 1983).

The only serious attempt to reduce ripening grain damage by reducing roosting populations has been in Quebec, where spring roosts of Red-winged Blackbirds (*Agelaius phoeniceus*) were sprayed with PA-14. These temporary roosts contained birds that bred locally and contributed to the late-summer damage problems. Furthermore, the roosts contained few nontarget birds in early spring. The approach "was judged to have limited merit at best" because of the logistic costs, limited period of roost occupancy, meteorological conditions required for surfactant spraying, disproportionate number of males in the roosts, and limited availability of large roosts in suitable habitat (Weatherhead 1982).

Common Crow (*Corvus brachyrhynchos*) damage to grain crops has always been a localized problem in North America. From 1934 to 1945, 127 crow roosts were dynamited in Oklahoma in winter to reduce waterfowl egg predation and damage to grain crops. Over 3.8 million crows were killed, but no evidence was obtained to indicate the explosions influenced total population levels or agricultural damage during the 12-yr period (Hanson 1946).

## Miscellaneous Lethal-control Operations

Murton *et al.* (1974) analyzed the effect of shooting to reduce numbers of Woodpigeons (*Columba palumbus*) damaging agricultural crops in a 10-$km^2$ area in England. Over a 12-yr period, the removal of up to 60% of the pigeon population in winter by shooting had no influence on subsequent spring population levels and damage. Decreased natural mortality rates of the surviving birds and immigration compensated for shooting mortality. The authors concluded that "shooting for crop protection can only be justified in those circumstances where pigeons are prevented from attacking vulnerable crops, and to a large extent the crop protection value of shooting depends on it acting as a scaring mechanism."

Larsen and Deitrich (1970) used DRC-1339 baits to reduce populations of 200 Common Ravens (*Corvus corax*) and 300 crows killing newborn lambs and blinding ewes on a ranch in Oregon. Populations were reduced 90% after baiting for 47 d, and losses were reduced from 72 lambs predated in the preceding year to 13. The next year, only 10 ravens and 50 crows were found on the ranch, and these populations were "quickly reduced."

## Conclusions

Considerable progress has been made in developing relatively safe methods for killing birds; large numbers can sometimes be killed and short-term relief from agricultural damage achieved. Few studies have examined the long-term effects of lethal control on pest populations or the benefits in relation to costs. Those studies that monitored population levels after the initial kill often showed that bird numbers quickly rebounded to pretreatment levels in the target area. Sustained relief from damage after killing generally occurred in locations where the pest population was isolated with limited potential for immigration, or where control was directed at the segment of the population immediately responsible for damage.

An improved understanding of the population dynamics and behavior of avian pest species is needed to complement the improved technology in killing birds. For most bird-damage situations, better estimates are needed for the total population numbers, the percentage and segment (species, sex, and age class) of the population involved in the damage, and the movement patterns and rate of immigration of the depredating population, especially in response to control programs. Also needed are more data on compensatory responses in survival and reproduction for pest populations subjected to a high rate of killing. These applied ecological studies should go hand in hand with the development and testing of lethal-control techniques. This will help ensure that lethal-control techniques are applied in the most judicious manner, that the killing of birds not involved in damage is minimized, and that lethal control is avoided in situations where only ephemeral, ineffective relief will result.

Most field evaluations of lethal-control techniques have put far more emphasis on determining the numbers of birds killed than on determining how much damage was eliminated in relation to the cost of control. Lethal control of birds in agricultural situations eliminates any beneficial attributes of the pest birds and involves some risks to nontarget organisms. It is imperative that developmental and operational costs of lethal-control techniques be considered in relation to the extent of damage reduction to ensure that future control programs are cost-effective. There are situations in Europe and North America in which a contact toxicant such as DRC-1347 or fenthion sprayed on roosting congregations of birds might be effective in reducing damage at nearby feedlots, grain fields, or orchards. However, the cost of research and development to register such toxicants would be high (G.A. Hood, unpublished data). Considering the limited situations in which such toxicants could be used and the high cost of registration in relation to the overall level of damage reduction, the pursuit of such a lethal-control strategy may not be cost-effective, especially when alternative means of reducing damage are available.

With regard to the use of pest birds as a food source, more effort should go into the utilization of the large numbers of pest birds killed on a sustained basis as a source of protein for humans and livestock.

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