February 2002

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Avery, Michael L., "Behavioral and Ecological Considerations for Managing Bird Damage to Cultivated Fruit" (2002). *USDA National Wildlife Research Center - Staff Publications*. 460.
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31 Behavioural and Ecological Considerations for Managing Bird Damage to Cultivated Fruit

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Introduction

Many bird species eat fruits and, likewise, many plant species are dependent on birds for the dispersal of seeds. Through cultivation and selective breeding, attributes of wild fruit have been changed to make fruit more palatable to humans. For example, cultivated species bear fruits that are often thinner-skinned, are more succulent, have fewer seeds and are easier to pick than non-cultivated species. These same changes, however, have also increased the attractiveness of fruit to avian consumers. Ecological relationships that have developed across evolutionary time between wild plants and frugivores become emphasized by the introduction of cultivated fruits that have been carefully bred, unknowingly and unintentionally, with bird-friendly traits.

Understanding depredations to fruit crops and developing effective means to reduce the impacts of depredating birds require an appreciation of the evolutionary and ecological bases for the birds' feeding behaviour. Unfortunately, research on avian depredation problems has seldom incorporated behavioural ecology. Rather, emphasis is often on development of methods that will mitigate a specific depredation problem in the short term, not on strategies that will effect durable, long-lasting solutions. The latter requires not only knowledge of immediate, local circumstances and management constraints (monetary, legal, societal), but also understanding behavioural and physiological adaptations of frugivorous birds. The array of fruit–frugivore interactions, particularly aspects such as optimal diet, flock dynamics and nutritional ecology, creates opportunities for wildlife managers and behavioural ecologists to collaborate in applying basic knowledge to important management issues.

On a national or regional scale, the economic impact of bird damage can be substantial. For example, a recent survey by the US Department of Agriculture produced an estimate of $41 million lost annually to wildlife damage in apples, grapes and blueberries (USDA, 1999). Most of the loss was attributable to birds. In addition, growers reported spending nearly $10 million annually to prevent wildlife damage, so the total economic impact currently exceeds $50 million annually for just three crops.

Whereas a loss of $41 million to birds is not trivial, it represents just 1% of the total annual apple, blueberry and grape production in the USA (USDA, 1999). If the losses were

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distributed evenly across all producers, there would be no bird problem. This is not the case, however. Bird damage is highly skewed, with most producers incurring little or no loss and a few producers having heavy losses (Hothem *et al.*, 1988; Johnson *et al.*, 1989). The percentage of the crop damaged by birds might be less than 5% overall, but this means little to a producer with losses of 20–25%. For extreme cases of bird damage, the most appropriate response might be to exclude birds from the crop with netting. This is also one of the costlier methods. Nevertheless, for certain commodities, including early-ripening blueberries and wine grapes, netting can be cost-effective (Fuller-Perrine and Tobin, 1993).

Damage by birds to cultivated fruit occurs worldwide. I shall not attempt a comprehensive review of all fruits affected and bird species involved, nor shall I attempt to describe the myriad of visual and aural bird deterrents that have been tested and are being marketed for control of bird damage to fruit crops (Avery *et al.*, 1988; Tobin *et al.*, 1988; Tipton *et al.*, 1989). Rather, I shall first discuss the use of non-lethal approaches to bird-damage management based on concepts of optimal feeding behaviour. This will be illustrated with the specific case of blueberry damage by cedar waxwings, *Bombycilla cedrorum*, in northern Florida, USA. Then, I shall consider population reduction as a possible component of integrated bird-management strategies and propose potentially useful areas for future research.

Feeding Behaviour and Ecology

Successful management of bird damage to cultivated fruits can be viewed within a conceptual framework largely derived from optimal foraging theory (Pyke *et al.*, 1977). Inherent in this framework is the idea of costs and benefits. To make a bird give up its preferred source of food, the fruit crop, the relative costs to the bird from feeding on the crop must increase to the point that alternative food sources become more profitable. The availability of alternative food sources is crucial. If the relative values of the alternative food and crop are similar, then the bird should readily abandon the crop for the alternative. If, however, the crop is substantially more valuable to birds than the alternative food, discouraging birds from feeding on the crop will be more difficult. For a variety of bird species, cultivated fruits provide nutritious, easily obtained food. With such great benefits there must be commensurately high potential costs to discourage birds from feeding on cultivated fruits.

Chemical Repellents and Crop Protection

Application of a chemical repellent to the crop is one non-lethal means of raising costs to depredating birds. There are two broad categories of avian repellents, primary and secondary, based upon their modes of action.

Primary repellents

Primary repellents are painful or irritating upon contact. The bird responds reflexively without having to learn an avoidance response. Many primary repellent compounds have relevance in interactions between birds and their natural prey (Clark, 1998). In the USA, one primary repellent compound, methyl anthranilate (MA), is the active ingredient in various formulated products marketed under the trade names of Bird Shield® and ReJeX-iT® (Avery *et al.*, 1996). These products are registered as bird repellents for use on cherries, blueberries and grapes.

MA is a naturally occurring compound used extensively in the food industry to give a grape or fruity flavour to sweets, chewing gum, soft drinks and other food items. Even though MA is safe and palatable to humans, birds do not like it. The repellence and mode of action of MA have been demonstrated experimentally through behavioural trials with nerve-cut and control birds (Mason *et al.*, 1989). Irritation and pain from MA are detected via the trigeminal nerve; all avian species tested so far perceive MA as an irritant, not as a taste repellent *per se*. The strong grapelike odour of MA is not aversive to birds (Clark, 1996). Birds must contact the MA-treated food in their mouths to experience the irritant effects. Rejection of

MA-treated food is contingent upon the options available to the bird. With no alternative food or with a relatively unattractive alternative food available, birds will continue to eat MA-treated food. If, however, MA-treated food is offered with untreated food of the same type, rejection of treated food occurs at much lower treatment levels (Avery *et al.*, 1995a). Because the irritation caused by MA may not be a very strong aversive stimulus, birds tend to return and resample the treated food. Thus, losses can accumulate even after the repellent is applied.

Secondary repellents

Secondary repellents are not immediately aversive but produce illness or discomfort after ingestion. Successful use of these compounds depends on the bird acquiring a learned avoidance response (Rogers, 1978). The bird must associate an adverse post-ingestional consequence with the appearance, smell or taste of the food, thereby learning to avoid it. For a bird, the consequences of ingesting a secondary repellent are potentially more dire than those of contacting a primary repellent. For this reason, an avoidance response produced by a secondary repellent is probably more robust than that produced by a primary repellent (Alcock, 1970; Rogers, 1974). A potential disadvantage to secondary repellents is that they are toxic and, for some compounds, there is not a great difference between a repellent dose and a lethal dose. The avoidance response is affected by various factors, such as the bird's prior experience with the food item, the strength of the post-ingestional discomfort and the availability of alternative food (Alcock, 1970).

Methiocarb (3,5-dimethyl-4-(methylthio) phenyl methylcarbamate) is an effective secondary repellent that has been used successfully in a variety of agricultural applications. As with other carbamates, its mode of action is via inhibition of acetylcholinesterase at synapses in the nervous system. Unlike many cholinesterase-inhibiting compounds, however, the effects of methiocarb are rapidly reversible, so disruption of the nervous system is only transitory. Applied properly, methiocarb is safe with regard to target and non-target species (Dolbeer *et al.*, 1994). Free-feeding birds acquire a repellent dose and stop feeding long before a lethal dose is ingested. The chemical has been tested extensively in many agricultural applications, including newly seeded and sprouted crops, ripening grain crops and soft fruits (Bailey and Smith, 1979; Conover, 1982; Porter, 1982). It was commercially sold as Mesurol® and formerly registered in the USA as a bird repellent on cherries, grapes and blueberries. In the USA, however, there is no current registration because of human health and safety concerns related to the cholinesterase-inhibiting action of the compound.

Another secondary avian repellent with potential utility in cultivated fruit is 9,10-anthraquinone. Birds that ingest food treated with the compound subsequently vomit and experience gastrointestinal discomfort (Avery *et al.*, 1997). Affected birds are not incapacitated, however, and there is no known effect on the nervous system. It is interesting that 9,10-anthraquinone has structural similarities to emodin, a powerful antifeedant found in fruits of *Rhamnus cathartica* (Sherburne, 1972; Avery *et al.*, 1997). In the USA, a formulated product called Flight Control® contains 50% anthraquinone and is currently registered for use as turf treatment to deter geese and other grazing birds (Blackwell *et al.*, 1999).

For fruit crops, test results with anthraquinone look promising. To examine frugivore responses to the repellent under controlled conditions, we conducted a feeding trial to expose cedar waxwings to technical-grade anthraquinone. We mist-netted 28 cedar waxwings in a blueberry field near Gainesville, Florida. Birds were caged individually and randomly assigned to four test groups of seven birds each. We quantified their consumption of a banana-mash diet (Denslow *et al.*, 1987) during 4 pretreatment days, and then assigned each group to receive one of four dietary concentrations of anthraquinone: 0, 500, 1000 or 10,000 p.p.m. in the banana-mash diet. As during pretreatment, birds were offered one cup containing the test diet for 3 h on four consecutive mornings. We videotaped one bird in the 10,000 p.p.m. group on the final pretreatment day and on each treatment day.

Consumption data were analysed in a repeated-measures analysis of covariance, with *the birds' pretreatment consumption as the* covariate. Over the 4-day treatment period, consumption varied ($F_{3,24} = 162.21$; $P < 0.001$) among treatment groups (Fig. 31.1). Mean consumption by the 10,000 p.p.m. group ($\bar{x} = 4.11$ g, SE = 1.11) and by the 1000 p.p.m. group ($\bar{x} = 10.51$ g, SE = 1.62) was reduced ($P < 0.05$) relative to the 0 p.p.m. group ($\bar{x} = 19.41$ g, SE = 1.54). There was no interaction between day and test group ($F_{9,71} = 1.82$; $P = 0.079$), as the birds responded very quickly to the adulterated diet. On the final pretreatment day, the videotaped bird averaged 5.5 bites (SE = 0.6) from the food cup during 15 feeding bouts and averaged 437 s (SE = 49) between bouts. When the anthraquinone treatment was added to the diet, the number of bites averaged 2.4 (SE = 0.6) during 12 feeding bouts. The mean interval between bouts remained the same (439 s), but there was considerably more variation (SE = 129 s). The range of inter-bout intervals during pretreatment was 134–697 s, compared with 71–1497 s during the initial treatment day. The greater variation in intervals between feeding bouts on the treatment day reflects uncertainty by the bird as it unexpectedly experienced post-ingestional discomfort after feeding where it had previously encountered only palatable food. On subsequent treatment days, the number of feeding bouts seen on videotape was 0, 2 and 0, respectively.

Limited field trials of the anthraquinone product, Flight Control®, in table and wine grapes in New Zealand and in cherries in the north-western USA have also produced encouraging results. Federal registration for these and other food-crop uses awaits further regulatory approval.

Increasing Costs to the Bird through Selective Crop Breeding

Reducing the quality of the crop as a food source for birds is potentially accomplished by altering attributes of the fruit through selective breeding. The objective of selective breeding is to increase the effort the bird has to expend to feed on the crop. Costs can be increased in different ways.

Food handling

Manipulation of the food item is an important commitment of time and effort (Pyke *et al.*, 1977). Intuitively, as the potential value of a food item increases, in terms of caloric value or nutrient content, so should the amount of time the bird is willing to spend manipulating and consuming it.

In northern Florida, the recent introduction of early-ripening varieties of blueberries, *Vaccinium* spp., has created an abundant food source in March, April and May, which overlaps the period of cedar waxwing occurrence in Florida (Nelms *et al.*, 1990). In addition, the

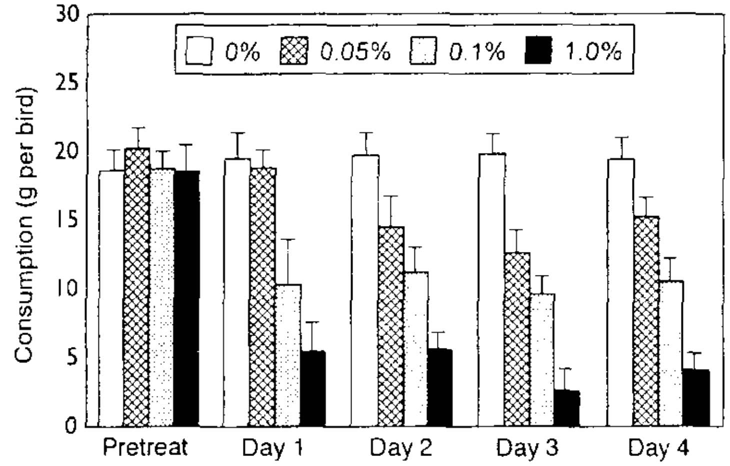

Fig. 31.1. Mean daily consumption by cedar waxwings ($n = 7$ per treatment) of banana mash treated with technical anthraquinone. Birds received one cup for 3 h on four consecutive mornings. Pretreatment values represent mean consumption of untreated banana mash during four daily 3 h trials.

availability of naturally occurring berries is particularly low in March in northern Florida (Skeate, 1987). The result is that blueberries (or other cultivated fruits) can represent an important food source for waxwings prior to their northward migration. We examined whether berry size and maturation date affect cedar waxwing damage to blueberries.

At the Horticultural Unit of the University of Florida (Gainesville, Florida, USA), we selected several cultivars with varying ripening dates and berry sizes. Following standard procedures (Nelms *et al.*, 1990), we evaluated berry loss from test bushes and assigned each blueberry cultivar to one of five damage categories: 0–20%, 21–40%, 41–60%, 61–80% and > 80% of fruits removed. We then determined the mean ripening date and berry size for each of the damage categories (Fig. 31.2). Results showed that varieties that produce small berries and that ripen early incur the greatest losses. The high level of loss among the earliest varieties is not surprising (Tobin *et al.*, 1991). For migrant and wintering birds at this time of year, there are few wild sources of fruit in northern Florida. Damage becomes less intense as wild fruits ripen in subsequent weeks.

The apparent berry-size selectivity demonstrated by birds in the field could be an artefact of early varieties being small-berried. To test directly whether cedar waxwings prefer small berries, we conducted a series of feeding trials with captive birds in which each bird was offered two berries that differed in size (Avery *et al.*, 1993). We recorded the fruit that was taken first and the time that the bird took to handle and swallow or drop the berry. We found that cedar waxwings do indeed prefer smaller-sized berries. The birds are almost perfect in their handling of the small berries; they drop very few and the time to swallow them is very short. In contrast, as berry size increases, the risk of dropping the fruit increases, as does the time it takes to swallow the fruit. The net result is that cedar waxwings do best, *in terms of rate of energy* gain, with smaller blueberries, even though larger fruits contain greater caloric rewards.

Breeding for larger fruit size might contribute to reduced berry loss, particularly if depredating birds have alternate food sources that are more efficiently handled and eaten. Alternatively, if waxwings persist in attempts to eat the larger fruit, they might actually damage more fruit by repeatedly plucking and dropping the big berries as they unsuccessfully attempt to consume the fruit.

A similar situation exists in Spanish olive orchards, where cultivated olives are twice as large as native olives. The larger size makes swallowing the fruit difficult or impossible for smaller frugivores, so bird species such as the blackcap, *Sylvia atricapilla*, opt to peck the fruit instead (Rey and Gutiérrez, 1996). If switching from swallowing to pecking is a widespread response by frugivorous species, then increased numbers of pecked fruit would probably negate any advantage of selectively breeding for larger fruit size.

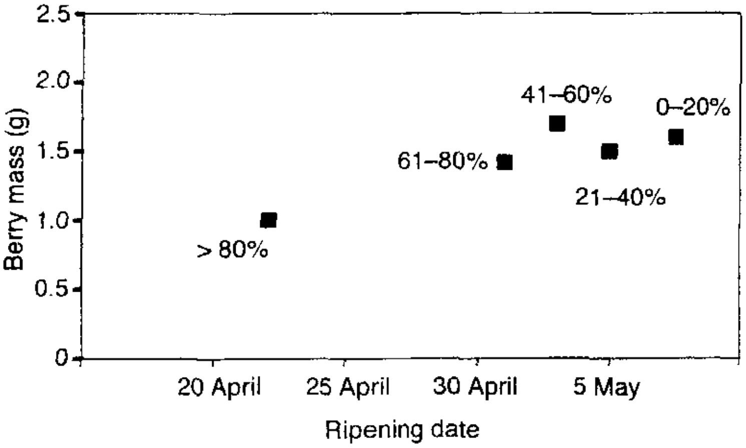

Fig. 31.2. Blueberry mass and ripening date relative to five categories of bird damage (0–20, 21–40, 41–60, 61–80, > 81% crop removed) in north-central Florida.

Digestive constraints

After ingestion, a food item still has to be digested and assimilated for the bird to benefit. Modification of the food item so that it is rendered more difficult to digest will reduce its attractiveness to depredating birds. Some frugivorous bird species, including major crop-depredating species, such as the American robin, *Turdus migratorius*, and the European starling, *Sturnus vulgaris*, possess a physiological constraint that makes it impossible for them to digest sucrose, a common constituent of many fruits (Martínez del Rio, 1990). These bird species lack the intestinal enzyme sucrase, which hydrolyses the 12-carbon sucrose molecule, which cannot be assimilated, into the six-carbon sugars glucose and fructose, which are assimilable. Means of exploiting this digestive constraint so that cultivated fruits will be less susceptible to bird damage include using sucrose as a spray on ripening fruit (Socci *et al.*, 1997) and manipulating the sugar composition of ripening fruit to produce elevated, bird-resistant levels of sucrose (Darnell *et al.*, 1994). Laboratory feeding trials have confirmed the potential usefulness of the latter approach to bird-damage reduction (Brugger *et al.*, 1993), but practical application remains to be tested. Furthermore, some frugivorous species when confronted with sucrose-rich fruit might consume more rather than less fruit. For example, cedar waxwings are able to digest sucrose, but relatively inefficiently, due to rapid gut passage rate (Martínez del Rio *et al.*, 1989). Consequently, to obtain the same energetic benefit, a cedar waxwing must consume more high-sucrose fruit than fruit that contains only glucose and fructose (Avery *et al.*, 1995b).

Alternative Sources of Food

The failure to appreciate the need for alternative feeding sites or food sources is a major impediment to initiating effective, ecologically based avian pest-management systems. Birds have to eat, and, as long as basic physiological needs are met, they will follow the path of least resistance. Application of virtually any method to protect a valuable crop from bird depredation will be more effective if alternative food is available. Novel though it might sound, the provision of such alternative food should be seriously considered and should be factored in as a cost of production by growers faced with persistent bird problems. For example, planting small-berried blueberry cultivars as alternative food sources for depredating cedar waxwings might fit well within an integrated bird-damage management plan. There is currently little interest on the part of blueberry producers in implementing this approach, however, and maintenance of the smaller-berry alternative bushes is a cost to producers that is not easy to bear. Establishment of feeding sites specifically for pest birds is probably not intuitively pleasing to most producers, and the effectiveness of this management approach needs to be experimentally tested.

Population Dynamics – Lethal Control of Problem Birds

Reducing the number of birds in the depredating population is seemingly a logical way to reduce crop damage. In the USA, lethal control has been facilitated by exempting some crop-depredating species, such as the red-winged blackbird, *Agelaius phoeniceus*, from protection under federal laws. Non-indigenous bird species in the USA, such as the European starling, are likewise not protected by federal laws. Thus, farmers can use lethal measures on some bird species as long as their actions are in accordance with local statutes and regulations. Most problem species, however, such as the American robin and cedar waxwing, are federally protected, so lethal control measures are only available under special permits, which are often difficult to obtain.

One of the major objections to lethal control is that it might not be effective in reducing damage. There is merit to this objection, as there are very few studies that clearly demonstrate an economic benefit to lethal control of depredating birds. Elliott (1964) reported that, during 1963, over 110,000 starlings were trapped and removed in eastern Washington, and that this effort 'practically eliminated' damage to the cherry crop in the Yakima Valley. During a 4-month period, Larsen and Mott

(1970) reported trapping over 3500 house finches, *Carpodacus mexicanus*, from a 0.4 ha blueberry planting near Portland, Oregon. There was no quantitative assessment of crop loss, but the grower felt that damage was 'considerably less' than in previous years. Palmer (1970) reported that bird damage at a California fig orchard dropped from 11% in 1967, when no control was applied, to 2.4% and 1.4% in 1968 and 1969, respectively, following the imposition of a trapping and poisoning programme. During the 2-year lethal-control effort, an estimated 53,000 house finches were removed. In Israel, mist-nets were used for 10 days in a 10 ha vineyard to remove about 2700 house sparrows, *Passer domesticus* (Plesser *et al.*, 1983). As a result, bird damage, which totalled $4500 in the previous year, was eliminated.

In Belgium more unconventional means of lethal control have been employed. Between 1972 and 1978, Ministry of Agriculture personnel used dynamite to destroy 22 starling roosts, killing an estimated 750,000 starlings (Tahon, 1980). The short-term impact of the programme provided some protection for the second half of the cherry season, although no crop-loss data are provided. In the long term, there was no measurable effect on the starling population from year to year, and the ultimate cost-effectiveness of the roost destruction programme was undetermined.

In the Rio Grande Valley of south Texas, great-tailed grackles, *Quiscalus mexicanus*, cause millions of dollars in damage to citrus crops by pecking holes in the skin of the fruit (Johnson *et al.*, 1989). Several non-lethal methods have been tried to reduce such damage, but none has proved practical or cost-effective (Tipton *et al.*, 1989). As a result, attention has shifted to lethal control. In particular, recent evaluations of improved trapping methods and baiting using the toxicant DRC-1339 (3-chloro-4-methylbenzamine hydrochloride) have proved promising for reducing local grackle populations in late summer, when damage problems are greatest (Glahn *et al.*, 2000). The baiting strategy involves putting the toxicant in water melon on elevated bait platforms, thereby providing the grackles with an irresistible food and water source during a very dry time of year. Field trials of the trapping and baiting methods not only showed their effectiveness for removing grackles, but also demonstrated that both control methods pose little danger to non-target species (Glahn *et al.*, 2000). Nevertheless, conclusive data on levels of damage reduction remain elusive.

Efficacy of lethal control

It is evident that large numbers of crop-depredating birds can be killed relatively quickly through judicious use of traps, poison and explosives, and, in fact, most lethal control programmes have focused more on documenting the numbers of dead birds than on quantifying the effects on crop damage. Although it seems reasonable that local, short-term crop protection can be achieved through reduction in depredating bird populations, quantification of the relationship between the number of birds killed and the associated reduction in crop damage is lacking. The prevailing attitude seems to be: 'A dead bird does not eat fruit.' A corollary is that the best damage-control strategy is to kill as many birds as possible.

It is hard to argue against the tenet that dead birds do not eat fruit, but it should be possible to devise a more scientifically based approach for lethal management. A lethal control programme ought to start with a clearly defined objective regarding the number of birds that are to be killed. I am aware of no instance in which an a priori analysis of the crop-damage situation has been conducted and a goal established for damage reduction through the removal of a specified target number of birds. In principle, at least, it should not be difficult to determine the amount of damage that can be accepted by a grower in a particular vineyard or orchard. Then, by applying appropriate techniques, the population could be reduced to the specified target level corresponding to the amount of expected damage.

I pose a simple hypothetical example to illustrate this point. Assume that a blueberry producer harbours 5000 house finches on a 25 ha farm. Further assume production of 2000 kg blueberries ha^{-1} and that one house finch can consume 1 kg of blueberries per growing season. Thus, if unchecked, the 5000-bird flock will consume 5000 kg, or 10%

of the expected blueberry production. The grower cannot accept this level of loss but is willing to accept a 2% loss, which corresponds to 1000 kg of blueberries. Under these conditions, the house-finch population should be reduced to 1000 birds, which means that 4000 birds have to be removed. A lethal control programme would then be devised to accomplish this objective and the progress of the programme monitored throughout the control period to evaluate its effectiveness in achieving the target mortality level.

Conservation and Management Implications

Non-native species

Introduced species play an important role in fruit-crop depredations. In the USA, the European starling is the major avian pest to crops of apples, blueberries and grapes (Avery *et al.*, 1994; USDA, 1999). A concerted, coordinated effort to reduce starling populations nationwide would not only provide relief from crop damage but would probably benefit native cavity-nesting birds, which must compete with the starling for limited nest sites (Weitzel, 1988). Another non-indigenous species, the monk parakeet, *Myiopsitta monachus*, is not a widespread problem in crops at this time, but damage by it to tropical fruit in south Florida is locally serious (Tillman *et al.*, 2001). Initiation of a population-reduction programme for monk parakeets before major depredation problems develop would be prudent.

Lethal control of native species is often difficult to justify, because such species possess beneficial attributes as part of the natural avifauna. Nevertheless, lethal control of native birds should be considered when sufficient information exists that economic losses are occurring and when reasonable target levels of mortality can be specified and achieved without jeopardizing non-target species.

Scale of management

The scale of the management effort is an important but neglected aspect of bird damage control. Depredation problems are at the field or orchard level – the scale at which we normally attempt to solve problems. The birds that are causing problems, however, can cover much more territory in a day. Because of their mobility, it might be most appropriate to design management strategies at the landscape level, taking into account movements and habitat use of the depredating species, as well as the temporal and spatial distribution of requisite resources. Much damage to fruit crops is done by large post-breeding flocks dominated by juvenile birds. If a broader temporal perspective to damage management is adopted, then perhaps measures could be initiated earlier in the year to limit reproduction by the target species so that fewer offspring are produced and the size of depredating flocks is reduced.

Improved methods

Tools at the field level will still be needed even if a landscape approach to management is adopted. To protect non-target species, nonlethal methods are preferred. Safer, more cost-efficient chemical repellents would help ease the depredation pressure experienced by growers and reduce the demand for lethal control. Repellents will not be the sole answer to bird depredations in fruit crops (Crabb, 1979), but they do represent an important component of an integrated programme.

Another non-lethal crop-protection method, the development of fruit cultivars with bird-resistant traits, has received little attention to date. One intriguing possibility is to develop fruit varieties that possess bird-resistant chemical defence compounds that are gradually deactivated as the fruit becomes ripe and ready to harvest. This is apparently the defence strategy that has developed in *R. cathartica* (Sherburne, 1972), and there is a precedent for it in crop breeding. In response to bird depredation, varieties of sorghum were developed that contained bird-resistant levels of tannins during early stages of grain development but which ripened into nutritional, palatable grain (Bullard and York, 1996). Successful application of this model to cultivated fruit would be a major breakthrough.

The usefulness of naturally occurring defensive compounds is largely unexplored. An example that merits further exploration centres on the damage done to pear buds by bullfinches, *Pyrrhula pyrrhula* (Greig-Smith *et al.*, 1983). These birds display preferences for certain pear cultivars over others, depending on the chemical constituents within the flowerbuds (Greig-Smith, 1985). One of these constituents, cinnamamide, was ultimately identified as a potentially useful bird repellent (Crocker and Perry, 1990; Crocker *et al.*, 1993). Further collaboration between evolutionary ecologists and wildlife managers might reveal additional naturally occurring anti-herbivory compounds that could prove useful for crop protection.

Avian conservation and agriculture

There is increasing recognition that agricultural areas can be important to avian conservation (Johnson, 1997; Shahabuddin, 1997; Hobson, 1998), so a major challenge is to find ways for agriculture and birds to coexist amicably. Too often, attractive feeding opportunities in crop habitat are over-exploited by a few problem species, provoking responses by growers that are detrimental to all species using the resource. In certain situations, incentives from government and private sources might be provided for producers whose agricultural activity supports bird populations (Huner, 2000). Alternatively, perhaps coalitions of government and private conservation organizations can work with agricultural producers to establish and maintain alternative feeding sites for crop-depredating bird species. Whatever form it takes, increased communication between agricultural producers and avian conservationists is crucial so that the needs and expectations of all interests can be better understood and appreciated.

Acknowledgements

Paul Lyrene provided access to blueberry cultivars at the University of Florida Horticulture Unit, and Kelly Goocher was principally responsible for compiling field data on bird damage to blueberries. Arlene McGrane assisted with feeding trials and Kandy Roca supervised care of the captive birds. Doug Levey, Mark Tobin and Kirsten Silvius provided helpful comments on the manuscript.

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