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ABSTRACT: Bird damage to early-ripening Florida blueberries was estimated to be approximately 17% in 1988 (2 sites) and ranged from 17% to 75% in 1989 (3 sites) when a late winter freeze severely reduced expected yield. Monetary loss due to bird damage in 1989 may have exceeded $4500/ac at one site. In Florida, birds appear to have a significant impact on the early-season fresh market blueberry industry. The problem is likely to worsen as the planting of high-value, early-ripening varieties spreads to other parts of the state and ripening times overlap with wintering frugivorous birds.

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INTRODUCTION

In the United States, blueberries are grown on approximately 40,000 ha (Hancock and Draper 1989) and have an annual market value greater than $160 million (A. Galleta, North American Blueberry Council, pers. comm.). Florida represents a small segment of the nationwide industry with approximately 800 ha in cultivation of blueberries (Hancock and Draper 1989). Much of the Florida blueberry production consists of U-pick operations, but an ever-increasing amount of early-ripening highbush blueberries are being grown for the fresh market (Lyrene and Crocker 1987). The early-ripening berries, those that are harvested from mid-April through May, are particularly valuable because they are the first to reach fresh markets.

Market factors have been paramount in motivating development of the early berries. In mid-April, there is no source of fresh blueberries except those from Florida, and the price for the first shipments of berries exceeds $10/pound. The price remains high ($5-$7 per pound) until the early Georgia and North Carolina berries reach the market. There is thus a high-reward incentive for Florida growers to plant the early-ripening varieties.

Accompanying the high-reward potential is high risk, however. Plants that produce ripe berries in mid-April must flower in January and February when sub-freezing temperatures are not uncommon. A prolonged midwinter freeze will kill the early blossoms and decimate the early blueberry crop (Anonymous 1989).

The second major risk factor that limits production of early Florida blueberries is bird damage. The principal species involved is the cedar waxwing, Bombycilla cedrorum. This species breeds during the summer in coniferous habitat in the northern United States and Canada and spends the winters in the southeastern United States and Central America. By March in northern Florida, the availability of naturally occurring winter berries is very low (Skeate 1987). For waxwings and other frugivorous species, ornamentals and cultivated fruit represent important food sources at this time. In April, when blueberries become available, there are still many waxwings that have spent the winter in the area or that are passing through on their northward migration. Previously, the waxwings' period of residency in Florida did not overlap the period of blueberry availability, but the advent of early-ripening cultivars changed this relationship (Fig. 1). The result is that now there is substantial overlap between the blueberry crop and the waxwings' period of residency, and this has created a serious local damage problem. Because berries are so valuable in April and May, bird damage during this period has a disproportionate economic impact. Compared to the overall blueberry crop, the early-ripening blueberries have a relatively limited exposure to bird damage, both in terms of time and acreage, but the value of the berries lost to birds is much greater in the early weeks of the season than during the rest of the summer.

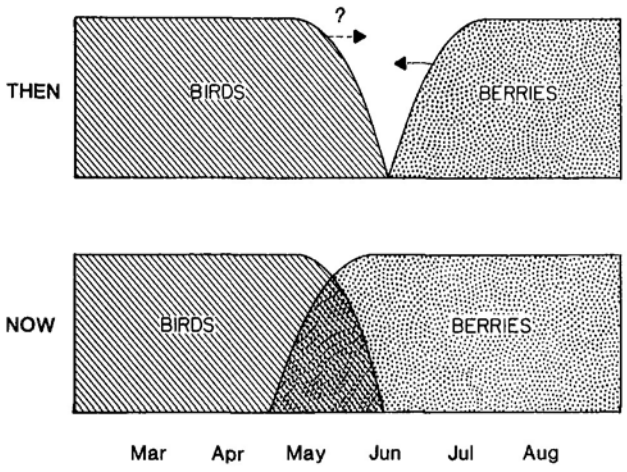

Fig. 1. Relationship between periods of cedar waxwing residency and cultivared blueberry availability in northern Florida before (THEN) and after (NOW) the introduction of early-ripening varieties.

Determining the amount of damage caused by birds is a necessary but often neglected aspect of the research process. In 1988 and 1989 we sampled growers' fields and plantings at the University of Florida Horticulture Unit to determine the level of bird damage to the early-ripening blueberry crop.

DAMAGE ASSESSMENT METHODS

1988

University of Florida Horticulture Unit.--Fourteen pairs of bushes (14 cultivars) were chosen and marked with flagging tape. Each pair consisted of plants bearing similar quantities of fruit. Members of a pair were separated by at least one bush. One bush of each pair was randomly (coin toss) assigned to be protected, the other unprotected. On each

bush, 2 similar branches were marked with aluminum tags inscribed with an identifying number. Numbers of berries distal to the tags were counted and recorded just before exclosures were erected on 19 and 20 April 1988.

Protected plants were enclosed in cages made up of 3 or 4 wire-covered panels. Each panel was a 4 x 6-foot rectangular frame made of 1 x 2-in western redcedar, covered with 1-in hexagonal poultry mesh. Panels were erected around the bushes with the tall sides vertical, and the frames joined with twisted wire. Cotton netting of 1-in mesh was draped over the tops of the completed triangular- or square-based cage thus formed.

Counts on both protected and unprotected bushes were made on 18 May, 26 May, and 1 June. During these counts ripe berries were removed from sample clusters and recorded so their fall would not affect subsequent counts. A final count was made on 8 June.

Protective measures employed at the Horticulture Unit by the University of Florida researchers included netting of some row segments, mylar reflective tape, eyespot balloons, pyrotechnics, and methiocarb treatments.

Florida Blueberries Inc., Gainesville .--Sixteen rows were randomly chosen from the center of the highbush planting (rows 15 to 65 of the total 77 rows). In each row, 2 bushes of similar stature were picked to form an assessment pair. On each bush, 2 branches were chosen and the fruit counted as previously described. On the protected bush of the pair, the chosen branches were enclosed in envelopes formed from stapled plastic fly screen immediately after counting on 27 April.

Berries on the unprotected marked branches were recounted on 10 May, just before the first commercial picking. All ripe berries were recorded and removed from the marked branches as they were counted. Unprotected berries were again counted on 19 May, and a final count of unprotected and protected samples was made on 23 May. Because of vandalism, 8 of the total 16 protected samples could not be used.

We operated 1 or 2 crow traps near the highbush planting from 28 March to 9 May. No other protective measures were employed on this planting until 11 May, when the grower installed a crow trap nearby, and on 12 May he applied methiocarb with an airblast sprayer.

1989

Caluka Farm.-- No formal damage assessment was conducted at this site. We initially visited the farm on 5 May after learning of the presence of hundreds of cedar waxwings. We made subsequent trips in May to observe waxwings feeding on blueberries and to capture birds for laboratory feeding trials.

University of Florida Horticulture Unit.--With minor exceptions, the same procedure was employed as in 1988. Twelve pairs of bushes (9 cultivars) were chosen, and enclosures were erected on 4 May. Berry counts were made at weekly intervals until 1 June. On each visit, all ripe berries on each bush were removed and weighed to obtain estimates of total yield per plant. In addition, five 5-berry samples from each cultivar were weighed to obtain an index to berry size.

Florida Blueberries Inc., Waldo-- This farm is laid out with lettered blocks and numbered rows. Also the sprinklers are laid out in a grid pattern, each being sequentially numbered. For damage assessment, 8 plots were set up, each consisting of 10 bushes in the same row between 2 sprinklers. These plots were blocked according to their proximity to the woods' edge. Four plots were haphazardly selected within 100 m of the treeline and 4 were selected at least 400 m from the woods. The plots within each block were at least 5 rows apart.

Five sample bushes were selected in each plot using a set of computer-generated random numbers. One bush in each plot was enclosed with poultry wire panels and net as described previously. Four bushes in each plot served as unprotected samples and were flagged with small pieces of surveyor's tape. On each bush, 2 branches were identified with aluminum plant tags, and all the berries distal to the tags were counted. For each plot, estimates of berry droppage and bird damage (see below) were derived. These were averaged over plots to obtain estimates for the entire field. Two-level nested analysis of variance was used to evaluate differences in bird damage between blocks and among plots within blocks.

During the study period, 24 April-24 May, the samples were counted prior to each harvest by the grower. At each of the 7 counts, all ripe berries were removed to correspond with the harvest operation.

Estimation of Droppage and Bird Damage

The percentages of each crop lost to droppage and birds were estimated using the data from the protected bushes. At the Horticulture Unit, separate estimates were made for each variety. The number of berries picked by us from the protected, marked branches during the course of the study (P_p) was subtracted from the beginning count (N_{pi}) to obtain the expected final count (N_{Ef}):

$$N_{Ef} = N_{pi} - P_p.$$

The difference between the actual observed final berry count (N_{pf}) and the expected number was the number of berries dropped (N_{pD}):

$$N_{pD} = N_{Ef} - N_{pf}.$$

The number dropped was divided by the initial count to obtain a droppage rate (D):

$$D = N_{pD}/N_{pi}.$$

Drop was calculated separately for each protected plant and applied to the unprotected bush(es) in the assessment pair or plot. On the marked, unprotected branches, the difference between the initial (N_{ui}) and final (N_{uf}) berry counts, minus the number picked (P_u), represented the combined number of berries lost to droppage and to birds (N_{uL}):

$$N_{uL} = N_{ui} - N_{uF} - P_u.$$

The droppage rate (D), derived from the protected branches, was multiplied by the initial berry count (N_{ui}) on the unprotected bushes to obtain the estimated number of dropped berries (N_{uD}):

$$N_{uD} = D \times N_{ui}.$$

This was subtracted from the total number of berries missing (N_{uL}) and the result was the number lost to birds (N_{uB}):

$$N_{uB} = N_{uL} - N_{uD}.$$

If N_{uD} exceeded N_{uL}, then bird damage was zero.

RESULTS

Bird Damage Estimates

Florida Blueberries Inc., Gainesville 1988.--At the end of the 26-day study period, approximately 52% (549) of the 1,052 berries that were present at the beginning of the study were still on the marked, unprotected branches. Of the 503 berries that were removed, 325 (65%) were harvested by us, while the remainder (178) were lost to birds or were dropped prior to harvest. From the 8 unvandalized protected bushes, we obtained a mean drop estimate of 9.9% (95% confidence interval: 1.4% to 18.5%). By applying this estimate to the initial berry count (1,052), we obtained an estimated of 104 (15 to 194) berries dropped. Thus, the number lost to birds was 74, and the mean bird damage was estimated to be 14.7% within the 95% confidence interval 0% to 32.4%. The estimated droppage rate was quite variable and relatively high. It is likely that the actions of the investigators locating marked branches and counting berries contributed to the loss estimates. Furthermore, the fly screen stapled over the branches may have contributed to the berry drop on the protected bushes. Nevertheless, it seems apparent that droppage and bird damage were substantial decrements to the harvest.

Florida Blueberries Inc., Waldo 1989.-- Among the 8 enclosed bushes, berry droppage due to normal conditions such as wind, rain, and the constitution of the plants varied from 0 to 22.2% with a mean of 5.7% (95% confidence interval: 0 to 12.1%). The block near the woods suffered an estimated 18.2% loss compared to 16.4% for the block 400 m from the edge. This difference between blocks was not statistically significant (P = 0.622), nor was there any difference among plots within blocks (P = 0.845). Because of a late freeze, which destroyed over 80% of the potential crop, overall yields in 1989 were far below the expected levels. The harvest from this 36-ac (15-ha) site was 3,860 lb (1,752 kg) of Sharpblue blueberries. Based on the mean values, we estimate that 286 lb (130 kg) were lost to incidental droppage and 867 lb (394 kg) to bird depredation. Therefore, bird damage at this farm cost the grower approximately $9,312 (estimated using a mean value of $10.74/lb), or $259/ac ($621/ha).

University of Florida Horticulture Unit.-- Bird damage estimates ranged from 0 to 55.8% in 1988 and from 0 to 92.3% in 1989 (Table 1). Estimates of berries lost to droppage were substantially higher in 1988 than in 1989. Some of this difference may be attributed to more careful handing in 1989 of the bushes during counts that reduced the extent of investigator-caused droppage. Furthermore, berries were harvested more frequently in 1989, thereby reducing the likelihood of droppage. We suspect that in 1988 the actual droppage rate was somewhat lower than indicated (Table 1), and consequently the estimate of bird damage would have been greater.

Caluka Farm.-- Berries were harvested during 10 to 20 April 1989 after which a flock of at least 500 cedar waxwings arrived at the 6-ac (2.4-ha) site and consumed berries at a rate that precluded further harvest. The birds' actions occurred despite efforts by the grower to control them with propane cannons, mylar reflecting tape, Av-Alarm, and shotgun patrols. He did not use eyespot balloons because he tried them in 1988 and found them ineffective.

Table 1. Berry loss due to bird damage and droppage at the University of Florida Horticulture Unit, 1988-1989.

1988			1989		
	% Loss			% Loss	
Variety	Birds	Drop	Variety	Birds	Drop
6-19	55.8	10.9	85-15	92.3	0
85-15	29.5	4.9	85-12	75.6	7.7
Ga Gem	27.5	20.4	85-30	73.9	13.0
3-8	27.0	7.1	Ga Gem	70.7	0
2-1	26.0	8.4	NC1528	61.5	7.0
O'Neal	23.7	5.5	83-132	55.6	9.1
Sharp	20.6	2.1	83-13	54.5	0
83-135	18.9	15.6	73-2	0	0
84-40	15.8	2.8	84-40	0	0
84-41	15.4	8.4			
78-15A	0	11.6			
83-63	0	12.3			
83-98	0	6.0			
84-131	0	11.6			
N = 14			n = 9		
mean	18.6	9.1		53.7	4.1
s.d.	15.5	5.0		32.5	5.1

Normally, this grower expects to harvest approximately 6,000 to 8,000 pounds of berries per acre (6,700 to 8,900 kg/ha). In 1989, the harvestable crop was greatly reduced due to a late winter freeze, so a more realistic estimate of yield in 1989 was 600 to 800 lb/ac (670 to 900 kg/ha). Thus, the total harvest in 1989 should have been 3,600 to 4,800 lb (1,630 to 2,180 kg). He actually shipped less than 800 lb (363 kg), so the loss to birds probably exceeded 75%. Assuming the expected yield was 3,600 lb, at an average price of $10.74/lb, bird damage may have cost the grower $30,000.

Berry Size and Bird Damage

Three varieties were common to the 1988 and 1989 trials at the University of Florida Horticulture Unit, and in each year their respective bird damage rankings were similar (Table 1). Varieties 85-15 and Ga Gem incurred relatively high bird damage whereas 84-40 received relatively little damage. Although damage varied greatly among the large-berry

varieties, data from 7 varieties in 1988 and 9 in 1989 suggest an inverse relationship between bird damage and mean berry size (Fig. 2). This is intuitively reasonable because smaller berries are available to both small and large frugivores, whereas the larger berries will be available to only the larger species.

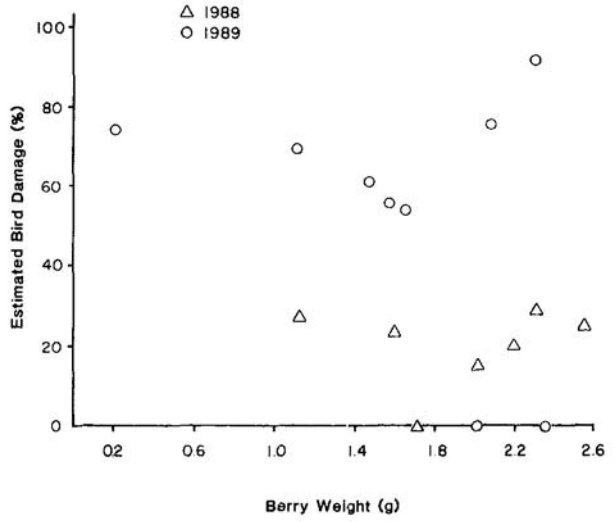

Fig. 2. Mean berry weight and estimated bird damage to blueberry cultivate at the University of Florida Horticulture Unit.

DISCUSSION

The information collected in 1988 and 1989 demonstrates that birds have a major economic impact on Florida blueberry production during April and May. Superimposed on the effects of late-winter freezes, berry losses to birds can substantially reduce a grower's prospects of a successful harvest.

The species most often implicated in blueberry damage during April and May is the cedar waxwing. However, in 1989 cedar waxwings were seldom observed at Florida Blueberries Inc. and the University of Florida Horticulture Unit and yet bird damage was still substantial at these locations. Numerous species contribute to the damage. At a given site, locally breeding species (crows, woodpeckers, northern mockingbirds, orioles, bluebirds, starlings) probably take a certain amount of fruit each year. In addition, crows break many branches by perching in the bushes. The effects of resident birds are predictable, and if the crop is not adversely affected by winter weather, their economic impact may not be great. For instance, in 1989 we estimated that birds took approximately 19 lb/ac (20 kg/ha) from the Florida Blueberries Inc. Waldo site. In 1989, this represented 17.3% of the yield. However, in a more normal year with harvest estimates of approximately 5,000 lb/ac (5,600 kg/ha), the 20 kg/ha loss rate represents 0.4% of the yield.

On the other hand, cedar waxwing damage is unpredictable, and when they are present these birds cause substantial damage. Two factors contribute the waxwings' effect. First they can be locally abundant with flocks often numbering in the hundreds. Secondly, because waxwings have a rapid food passage rate (Martinez del Rio et al. 1989), they probably consume more berries per unit time than do most other species. In addition to actual consumption, our observations suggest that these birds drop or knock off many berries as well.

Because of the high cash value of this crop, more acreage will likely be planted to early-ripening blueberries in the near future. There are already indications that the crop is spreading to more southerly areas of Florida where winter freeze damage is less likely (Anonymous 1989). The more southerly plantings will ripen earlier, perhaps in mid-March, and the time period during which blueberry availability and waxwing residency overlap will be extended. In addition, wintering American robins (Turdus migratorius), heretofore not a problem in Florida blueberries because they currently migrate north before cultivated blueberries are available, will likely become major pests as they are to blueberries in other parts of the country (Mott and Stone 1973).

Two aspects of damage assessment methodology deserve comment. First, we found that using plots consisting of 4 exposed plants and 1 enclosed plant was an efficient procedure for sampling bird damage to blueberries. The coefficient of variation in the number of berries lost from the 32 exposed plants was 78.7%. But, considered on the basis of 8 plots of 4 plants each, the coefficient of variation was 20.9%. At $\alpha = 0.05$, in order to detect a 20% difference in berry loss between 2 fields with 80% certainty, we estimate that 16 plots of 4 bushes each, or 64 total bushes, would have to be assessed. Conversely, using the individual plant as the sampling unit, approximately 256 bushes would have to be sampled to achieve the same degree of certainty. Also, unless ripe berries are removed frequently (every 3 to 5 days) during the damage assessments, it is necessary to include enclosed bushes in the sampling procedure in order to estimate berry loss not due to birds. Although some studies fail to do this (e.g., Conover 1985, Tobin et al. 1988), without controlling for droppage absolute bird damage estimates are suspect.

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