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Michael L. Avery
University of California, Davis, California

Richard DeHaven
U.S. Fish and Wildlife Service

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MICHAEL L. AVERY, Wildlife and Fisheries Biology, University of California, Davis, California 95616

RICHARD DeHAVEN, U.S. Fish and Wildlife Service, Denver Wildlife Research Field Station, 6924 Tremont Road, Dixon, California 95620

ABSTRACT: Bird damage was assessed weekly from soon after anthesis until harvest in two sunflower fields in the Sacramento Valley, California, during 1982. Damage chronology was similar at both sites, with damage concentrated in the second to fourth weeks after anthesis when the seeds were in the doughy stage of development. Less than 10% of the total losses caused by birds occurred during the final month before harvest. Overall bird damage was quite low (0.20 and 0.26%) in each field and in one, damage by wind was 2.4 times greater than that caused by birds. Brewer's blackbirds (Euphagus cyanocephalus) and house finches (Carpodacus mexicanus) both occurred in low-to-moderate numbers in one field, while high numbers of blackbirds, mostly red-winged blackbirds (Agelaius phoeniceus) occurred at the other field. At both fields, the numbers of blackbirds recorded peaked during the dough stage of sunflower development, whereas finches were most numerous somewhat later in the damage season. Analysis of the esophagi of 15 red-winged blackbirds collected at one field showed that in addition to sunflowers, various wild grass seeds and insects were consumed.

INTRODUCTION

Many species of birds, but principally blackbirds, damage ripening sunflower in the U.S. (Besser 1978). During 1980 and 1981, surveys of such damage were conducted in 60 sunflower fields in California's Sacramento Valley (Avery and DeHaven 1982). A majority (48) of these fields had bird damage estimated at <1%, while 12 fields had estimated losses >1%. Although blackbirds were frequently observed in the surveyed fields, house finches (Carpodacus mexicanus) were believed to be responsible for most of the damage.

Attribution of most of the observed bird damage to house finches was based mainly on observations made during a single damage survey conducted in each field just before harvest. However, it was not known if damage occurring earlier in the season was caused by species not present when the damage assessments were conducted. Thus, during 1982, two additional sunflower fields in the Sacramento Valley were selected for more intensive observations and damage assessments throughout the several weeks' period of damage susceptibility before harvest. Objectives were to evaluate (1) which bird species were present and causing the overall damage, (2) when during the season the damage occurred, and (3) where within the fields damage was greatest. Results of these evaluations are presented here.

METHODS

The criteria for selection of the two fields were that (1) the nearby habitat features appeared likely to be attractive to depredating birds, (2) bird damage to sunflowers grown in the vicinity had been relatively high in previous years, and (3) relatively large numbers of birds were present nearby.

In each field, 30 random plots, each consisting of 8 consecutive sunflowers in one row, were established for assessment of damage. The plots were allocated such that 10 occurred within each of three equal strata representing edge, intermediate, and central rows of plants. Each plot was marked with plastic flagging attached to the base of the plants near ground level. Damage was assessed weekly in each field beginning about 5 days after anthesis and until harvest, using the plastic template described by Dolbeer (1975) and the methods used by Avery and DeHaven (1982) in the earlier studies.

Damage caused by wind knocking the plants into each other was recorded separately from bird damage. Wind damage was usually readily identified by bending over the head to determine if the damaged areas (missing seeds) matched any points of contact with adjacent plants.

Observations of birds feeding were made whenever possible. Generally, the instantaneous activity and positions on the plant were recorded at 15-s intervals for individual birds as long as they remained in sight. Also, before each damage assessment, we recorded the number and species of birds seen while driving a vehicle around the perimeter of the field.

To supplement the field observations, the food habits of 15 red-winged blackbirds shot between 0730 and 1130 on 23 August as they fed in or were leaving one of the fields were evaluated. After collection, each bird was immediately injected with isopropyl alcohol, placed on ice, and then frozen within 6 h. All birds were later thawed and their esophageal contents removed and the food items identified. The proportion of each food type was determined by count, weight, and volume.

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STUDY SITES

Field number 1 was actually the northern half (about 30 ha) of a 60-ha sunflower field located adjacent to a tree-lined slough 7 km southeast of Woodland, in Yolo County, California. House finches were observed in the trees bordering the north and northwest sides of this field during our first visit, and they subsequently used the trees as a loafing area from which they flew out to forage in the sunflowers. We limited damage assessments to the northern half of the field because it appeared that this is where the damage would be concentrated. The surrounding fields were either fallow or planted with various crops.

The second study site was a 32-ha sunflower field located 8 km southwest of Willows in Glenn County, California. This field was part of a complex of six contiguous sunflower fields totaling over 200 ha amidst fields of rice, corn, and other crops, and it was chosen because several hundred blackbirds were present during our initial visit. These blackbirds ranged over the entire complex of sunflower fields during the course of the study. They also used a corn field 85 m northwest of the primary field as a loafing area and a marsh about 6.5 km to the southeast on the Sacramento National Wildlife Refuge as a communal roosting area.

RESULTS

Field 1

Between 3 August and 23 September, eight trips were made to field 1 to observe birds and assess damage (Table 1). House finches were present in the field beginning 17 August, with peak numbers on 6 September. Brewer's blackbirds (Euphagus cyanocephalus) were present on five of the eight visits, and peaked in numbers somewhat earlier than the finches. Maximum blackbird numbers appeared to roughly overlap with the period when the sunflower seeds were in the soft, doughy stage of development. Finches, however, were most abundant after the dough stage when the bulk of the seeds were firmer and drier. Except for small numbers of house sparrows (Passer domesticus), no other depredating species was observed.

Table 1. Summary of visits to two Sacramento Valley sunflower fields, 1982.

Date	Field condition	Number of birds/visit	
		House finches	Blackbirds[1]
	Field 1		
3 Aug.	Anthesis ending; field wet	several	none
9 Aug.	Anthesis past; field dry	none	65-70
17 Aug.	Seeds soft, wet	20-25	200-250
24 Aug.	Plants turning yellow	35-40	none
31 Aug.	Male plants down; seeds doughy	25-30	75-100
6 Sept.	Plants drier, brown; seeds firmer	60-70	75-80
13 Sept.	Plants stiff, dry; seeds hard	35-40	none
23 Sept.	Harvest in progress	20-30	25-30
	Field 2		
2 Aug.	Anthesis in progress	none	400-500
10 Aug.	Flooded; seeds very moist, soft	none	200-250
16 Aug.	Field still flooded	none	2500-3000
23 Aug.	Plants very green, moist	none	3000-4000
30 Aug.	Seeds doughy, moist	none	3000-4000
7 Sept.	Male plants down	none	2000-3000
13 Sept.	Plants drier; much wind damage	none	500-750
23 Sept.	Seeds firmer, but still moist	none	500-600
28 Sept.	Seeds hard, dry	none	none
4 Oct.	Seeds dry, plants brittle	none	200-300

[1]- Brewer's blackbirds in field 1, mostly red-winged blackbirds in field 2.

The blackbirds were seen only in the northeastern part of the field, while finches were most abundant in the northwestern section near the trees. Thus, it was possible to roughly partition the recorded damage within the field between the two species. On this basis, Brewer's blackbirds accounted for about 75% of the loss and finches about 25%. Therefore, the graph of cumulative damage (Figure 1) reflects mainly the depredations by blackbirds.

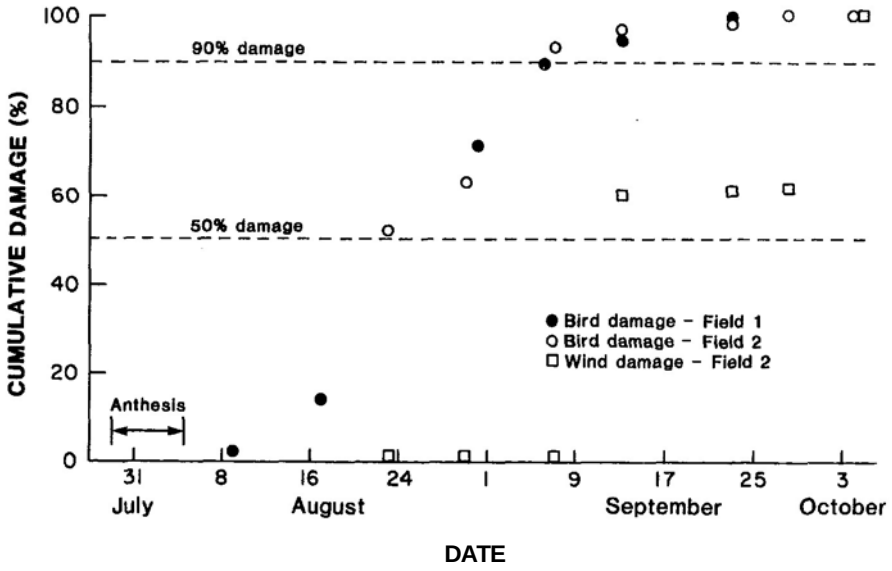

Figure 1. Cumulative bird and wind damage in two Sacramento Valley, California sunflower fields, 1982.

The overall estimated bird damage level in this field was 0.20% (±0.35; this and all subsequent ± figures within the text represent standard deviations of the respective means) (Table 2). Most of the loss was concentrated in the edge stratum, nearest the tree-lined northern border. Beyond the edge stratum, the damage declined sharply, perhaps indicating a reluctance of the birds to forage very far from cover.

Table 2. Summary of bird and wind damage in two Sacramento Valley, California sunflower fields, 1982.

	Field 1				Field 2			
	Stratum				Stratum			
	Edge	Intermediate	Central	Overall	Edge	Intermediate	Central	Overall
Number of plots								
Sampled	10	10	10	30	10	10	10	30
Damaged by birds	9	5	4	18	9	10	5	24
Damaged by wind	0	1	1	2	10	9	10	29
Number of heads								
Sampled	80	80	80	240	80	80	80	240
Damaged by birds	28	5	7	40	24	36	13	73
Damaged by wind	0	1	1	2	33	24	35	92
Head area damaged (cm^2)								
By birds	148	38	13	199	46	233	50	329
By wind	0	1	10	11	365	165	268	798
Mean % damage (± 1 s.d.)								
Birds	.44±.42	.13±.34	.04±.07	.20±.35	.11±.11	.54±.85	.12±.23	.26±.54
Wind	0	0	.03±.08	.01±.11	.89±1.1	.34±.40	.62±.51	.63±.75

Relatively few quantifiable observations were obtained on house finches feeding at this site because of the difficulty in maintaining continuous observance of individual birds. One problem was that soon after arriving in the field, many birds dropped down out of sight, probably to forage on the ground. Nevertheless, we did find that house finches feeding on female sunflower plants spent an average of 40 s (±16, n=12) handling and eating seeds that were usually plucked from the head as the

bird leaned over and reached down from its perch on the upper rim of the sunflower disc. In addition, 4 of the 22 finches that were observed for at least 45 s foraged among the remnants of seeds left by other birds in the concave back side of the head. One finch fed extensively from an Echinocioa seed head that was leaning against a sunflower plant.

Another finch observed feeding on male sunflower plants, which are smaller than female plants, ate 20 seeds in 148s. This rate of 0.14 seeds/s is much higher than the 0.03 seeds/s rate recorded for finches feeding on female plants. On one occasion, two finches persistently pecked at the back side of a dough-stage sunflower head and they appeared to be eating the moist, pulpy material. Subsequently, we found beak marks on several nearby plants, indicating that this behavior was not isolated.

Feeding activity and position observations of Brewer's blackbird were not possible in this field because the birds could not be approached without disturbance. However, in general, the Brewer's ate sunflower seeds while perched on the upper rim of the sunflower head and they were not observed foraging on the ground, unlike red-winged blackbirds (Agelaius phoeniceus) observed in previous years (Avery and DeHaven 1982).

Field 2

Ten visits were made to the second field from 2 August to 4 October (Table 1). However, because irrigation made the field impassable, the first damage survey could not be conducted until 23 August. By this time, about 52% of the final bird damage had already occurred (Figure 1). Moreover, about one-half of the final bird damage occurred within 3 wk of anthesis and about 93% occurred by the end of the dough stage of development. Thus, an extension of the graph of cumulative bird damage back to the anthesis stage would probably closely resemble that for the first field.

Generally, the numbers of blackbirds recorded in field 2 (Table 1) appeared related to the chronology of bird damage (Figure 1). In particular, the largest numbers of blackbirds (2,000-4,000) were recorded during the four counts made from 16 August to 7 September; before and after this period, blackbirds were only about one-tenth as numerous (Table 1). The blackbird populations recorded during the counts were composed mainly of red-winged blackbirds, although a few yellow-headed blackbirds (Xanthocephalus xanthocephalus) and brown-headed cowbirds (Molothrus ater) were also included.

Despite peak blackbird numbers totaling at least several thousand birds, the overall bird damage level for field 2 was only 0.26% (±0.54), a figure comparable to the 0.20% recorded for field 1 (Table 2). Damage by wind in field 2 totaled 0.63% (±0.75), about 2.4 times more than the bird damage (Table 2). The wind damage which occurred during the week following 7 September alone resulted in total seed losses greater than that from bird damage over the entire season.

The distribution of both bird and wind damage within field 2 was somewhat uneven among the three strata (Table 2). About 70% of the total bird damage occurred in the intermediate stratum, with the remainder about equally divided between the edge and central strata. In contrast, about one-half of the total wind damage occurred within the edge stratum. It appears that birds may have avoided the edge rows of sunflower where wind damage to the more exposed sunflower plants was highest and where damage control measures, including zon guns, and shotgun patrols, were being intensively used. However, the reason for the paucity of bird damage in the central stratum of the field is unknown.

Most blackbirds arriving in the field initially perched atop a sunflower plant without feeding for several seconds ($\bar{x}$ = 15s; range = 4-61; n = 13) and then dropped down, usually to an area out of our view. As a result, only eight blackbirds were observed actively feeding. Of these, the feeding periods ranged from 32 to 315s and an average of 4 (±2) seeds/min were taken. However, it was often difficult to determine whether a seed had actually been consumed. Nevertheless, expressed another way, the feeding data indicate that on average, 23 s (±20) elapsed from the taking of one seed to the taking of the next one and this figure includes an acquisition time of 1 to 5s for each successive seed. Thus, it appears that the actual sunflower seed feeding rate of blackbirds -- about 20 s/seed -- is about one-half that recorded for house finches.

Of the 15 red-winged blackbirds collected from this field, sunflower seeds and grass seeds were each identified from 14 birds, while insects were identified from 10. However, only 7 of the 15 birds actually contained food in their esophagus. Since the number of birds with esophageal food and the diversity of those foods were both quite small, the results of these 7 birds were pooled (Table 3). The pooled results show that grass seeds comprised 88% of the total number of prey items counted, but that sunflower seeds made up most of the weight (63%) and volume (61%) of the esophagi. None of the esophagi contained only sunflower seed. Among the grasses, Paspalum was the genus most commonly recorded, with lesser amounts of Panicum and Setaria noted. All three grass genera occur commonly within the study area. Among the insects recorded in the esophagi, small green caterpillars (Lepidoptera) and damselflies and dragonflies (Odonata) were the most numerous.

Table 3. Combined esophageal contents of seven red-winqed blackbirds collected at sunflower field number 2, Sacramento Valley, California, 23 August 1982. (Percent of total is given in parentheses).

Food item	Number of items	Weight (g)	Volume (ml)
Sunflower seeds	31	1.87	1.84
	(8)	(63)	(61)
Grass seeds	327	0.78	0.77
	(88)	(26)	(25)
Insects	13	0.31	0.43
	(4)	(11)	(14)
Total	371	2.96	3.04

DISCUSSION

The chronology of the bird damage which occurred in the two sunflower fields was similar. There was a gradual buildup beginning just after anthesis, followed by a steep rise in damage until about 4 to 5 wk after anthesis, after which little additional damage occurred (Figure 1). As this general pattern was similar for the two fields despite their quite different bird species compositions, some general guidelines for the application of bird damage control measures may be possible. For example, since with blackbirds the most susceptible time appears to be during the 2 to 4-week period of dough-stage development, this is probably when the most intensive control efforts should be applied. Also, because relatively little damage occurs after the seeds harden, control efforts can be either reduced or eliminated. In sunflower fields with large numbers of house finches, a different pattern, in which bird damage continues to accumulate until harvest, may apply. Unfortunately, from this study, the damage chronology pattern of house finches was not apparent because of the relatively low numbers of finches present.

Sunflowers are obviously only one component of the diet of blackbirds from within the study fields. This is exemplified by (1) the relatively low overall level of bird damage recorded in field 2 despite the thousands of birds present and (2) the presence of relatively large quantities of other prey items, especially grass seeds, in the birds which were collected.

It is interesting that none of the birds collected contained rice, a very common crop in the area and a major component in the digestive tracts of blackbirds collected by Crase and DeHaven (1978) in this same area. However, milk-stage rice is probably undetectable in blackbird esophagi (DeHaven, unpubl.), so possibly the birds we collected had also fed on this stage of rice. Alternatively, these birds may have preferred sunflowers to rice and may only adopt a rice-dominated diet when dough-stage sunflowers are unavailable. Since sunflowers are relatively new to the Sacramento Valley, and because overall acreages are relatively small, most Sacramento Valley blackbirds probably do not come in contact with this crop. Additional collections of birds for food-habits analyses from a larger area and over an extended period of time could help to establish the overall importance of sunflowers in the diet of blackbirds and other species.

CONCLUSIONS

Season-long monitoring of bird damage at these two fields in the Sacramento Valley, California, indicated that most bird damage occurred during the relatively short (2 to 4-wk) period of dough-stage development, and that the bird species present late in the season were the same species present earlier when most of the bird damage occurred. Blackbirds, despite their relatively high numbers, caused insignificant losses to either of the study fields. This finding is consistent with previous results (Avery and DeHaven 1982) from the same area and supports the conclusion that blackbirds are currently having a relatively small overall detrimental impact on the Sacramento Valley sunflower crop. Future research on bird damage to sunflowers in this area should probably concentrate on the house finch. In particular, an attempt should be made to determine if the damage chronology pattern of finches is similar to that found in this study. Such knowledge could help in designing the most effective bird damage control programs.

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