RED-WINGED BLACKBIRD AND STARLING FEEDING RESPONSES ON CORN EARWORM-INFESTED CORN

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ABSTRACT: We examined the feeding behavior of red-winged blackbirds (Agelaius phoeniceus) and European starlings (Sturnus vulgaris) on ears of corn (Zea mays) artificially infested with corn earworms (Helicoverpa zea). In 30-minute aviary tests, redwings and starlings directed 39 to 79% more feeding responses to ears of corn with worms than to ears without worms but they damaged the same proportion of ears with and without worms. In 3-hour aviary tests and a field evaluation, birds damaged more ears with worms than without worms. In spite of more feeding responses directed to ears with worms, the overall damage (number of kernels eaten by birds) was similar in both groups of ears in aviary tests. Our findings indicate that earworms can influence feeding behavior by redwings and starlings on ears of corn. The results generally support the hypothesis that by reducing insect populations in cornfields, one can make the fields less attractive to birds. Also, because redwings and starlings actively sought earworms in corn ears, these abundant birds have the potential for reducing populations of these insect pests in cornfields.

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INTRODUCTION

Various management methods have been developed to reduce damage to ripening corn by blackbirds (Icterinae), especially redwings. Methods include chemical frightening agents, mechanical noise devices, visual scaring devices, and bird-resistant cultivars of corn (Dolbeer 1980). These methods have shown inconsistency in their effectiveness, perhaps because they were developed with little consideration of ecological and agronomic factors that influence blackbird activity and damage in ripening cornfields (Dyer and Ward 1977, Dolbeer 1990). In addition, the possible beneficial role played by blackbirds in reducing insect pest populations in cornfields is often not considered in pest control strategies (Woronecki and Dolbeer 1980).

Previous studies (Bird and Smith 1964, Hintz and Dyer 1970, Mott et al. 1972) have shown that in late summer redwings shift from a predominately insectivorous diet to a predominately granivorous subsistence. Specific studies on the feeding habits of redwings in cornfields during this transition period showed that blackbirds commonly eat insects, especially corn rootworm beetles (Diabrotica longicornis), corn earworms, and European corn borers (Ostrinia nubilalis) (Mott and Stone 1973, Genung et al. 1976, Bridgeland 1980, Bendell et al. 1981, Gartshore et al. 1982, Bollinger and Caslick 1985a). Application of insecticides to ripening fields of sweet corn in Ohio reduced insect numbers, blackbird activity, and blackbird damage compared with untreated fields (Woronecki et al. 1981). Woronecki et al. (1981) hypothesized that an insecticidal-induced reduction of insects made the cornfields less attractive to blackbirds and resulted in less bird damage. In another study, sweet corn plots in New York treated with insecticide had significantly lower European corn borer populations and less blackbird damage than untreated plots, suggesting that the corn borer population attracted the redwings and that control of this insect pest reduced damage by birds (Straub 1989). Bollinger and Caslick (1985b) showed a positive correlation between rootworm beetle population levels in cornfields and the distance of the fields from a blackbird roost, which they hypothesized was related to redwing predation. Also, cornfields with high populations of rootworm beetles had significantly greater numbers of blackbirds during the silking period than did fields with low numbers of beetles (Bollinger and Caslick 1985a).

The degree to which starlings feed in cornfields on insects and ripening corn is less well known than for blackbirds (Woronecki and Dolbeer 1983). Stewart (1973) observed starlings feeding on corn earworms and fall armyworms (Spodoptera frugiperda) in cornfields without damaging kernels of corn. Somers et al. (1981) reported fresh corn in the gullets of 5 of 6 starlings shot in a ripening cornfield. Dolbeer et al. (1986) and Bernhardt et al. (1987) documented in aviary studies that starlings are fully capable of penetrating husks and feeding on ripening corn. In fact, starlings did substantially more damage to corn than did redwings in these aviary studies.

Additional research is needed to clarify the feeding behavior of blackbirds and starlings in cornfields in relation to insect populations and insecticide applications. These studies will help formulate integrated pest management strategies for corn to reduce damage by birds and insects while minimizing insecticidal use.

We conducted 3 experiments in the aviary and 1 in the field to determine the feeding behavior of redwings and starlings on corn ears with and without corn earworms. The following hypotheses were tested: (1) redwings will do more damage (number of kernels eaten) to ears of corn whose husks have been opened than to ears with untampered husks, (2) redwings and starlings will direct more feeding activity to ears with worms than to ears without worms, (3) redwings and starlings will damage a greater proportion of ears with worms than ears without worms, (4) redwings and starlings

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will inflict more damage (number of kernels eaten) to ears with worms than to ears without worms, and (5) the total damage to ears (kernels eaten by birds and worms) will be greater for ears with worms than without worms.

METHODS

Corn planting

The study was conducted in 1988 in Erie County, Ohio. Two sweet corn cultivars, Roger Bros. JAZZ and Agway GOLD DUST (referred to as SC1 and SC2, respectively), and 5 field corn hybrids, Glen Garno 1003, Cargill 7877, Crows 488, Walton WX35, and Pioneer 3295 (referred to as FC2, FC3, FC4, FC8 and FC9, respectively) were planted on 3 June 1988 in contiguous plots 6 to 18 rows wide by 73 m long. Row spacing was 0.75 m and plant spacing averaged 0.2 m.

At the onset of silking (late July) all plants with newly silked primary ears within each plot were marked at 2-day intervals with spray paint, using a different color paint for each marking day. This provided populations of ears of a known (within 1 day) silking date and allowed use of corn ears of the same maturity within each aviary test. Four maturities of each cultivar or hybrid were used for tests.

In each plot, the following treatments were randomly allocated to pairs of rows: (1) sprayed with insecticide, to provide ears free of corn earworms; (2) untreated control for monitoring the extent of natural corn earworm infestation; and (3) artificially infested with corn earworm to provide ears with earworms.

Methomyl (CAS number 16752775), formulated in the insecticide Lannate® at 216 g A.I./l, was applied in the insecticide rows at the rate of 0.5 ml of solution per ear from a hand-held sprayer. Methomyl has low repellency to redwings (R_{50} = 0.224%), as compared to methiocarb (R_{50} = 0.050-0.089%), an insecticide with documented bird-repellent properties (Schafer et al. 1983). The initial application for each maturity group of corn in insecticide rows was on the first silking day with 2 subsequent applications at 4-day intervals. There was a minimum of 5 days between the final application and the use of ears in a test (15 to 28 days after silking).

Manual corn earworm infestation

We initially infested corn ears in worm rows with corn earworm eggs suspended in 0.2% agar solution, using a calibrated pressure applicator (hand-lotion dispenser) at the rate of 60 to 70 eggs per silk mass (Wiseman et al. 1974). Infestation was done 1 day after silking (DAS) for each maturity. The development of larvae was monitored every 3 to 4 days by opening several ears to check for the size of the worms. Egg inoculation achieved only a 22% rate of infestation, perhaps because of a high incidence of the minute pirate bug (Orius insidiosus), a predator which feeds on eggs and first-instar larvae of the corn earworm in the silk channel. Other insect predators noted were ladybird beetles (Coccinellidae).

We therefore decided to artificially infest ears with corn earworm larvae 4- to 6-days old (Wiseman et al. 1974). About 2,000 eggs were placed in a 113-ml cup and incubated at ambient room temperature (25-38°C). After 1 or 2 days, neonate larvae were transferred to an artificial diet (Perkins et al. 1973). Larvae were checked daily and larger ones were isolated in 113-ml cups containing the artificial diet to reduce cannibalism of smaller larvae (Wiseman et al. 1974). At 12 DAS for sweet corn and 15 DAS for field corn, we artificially infested primary ears with 5- to 6-day-old larvae (5-8 mm long). A plastic drinking straw (0.5-cm diameter and 9-cm long) was inserted into the silk channel and the pointed wooden handle of a #2 camel's hair brush was inserted through the straw to the tip of the cob to create a tunnel for the worm. The brush handle was removed and 1 corn earworm larva was then guided into the straw with the brush. We gently blew through the straw while carefully withdrawing it, leaving the worm within the silk channel next to the cob tip.

Aviary testing procedures

The aviary contained 24 test cages made with 2.5 x 2.5-cm welded wire, each 1.5 m (length) x 1.0 m (width) x 1.0 m (height), suspended 1 m off the floor by cables. Each cage had a 1.5-m long perch located 0.2 m from the top. Two 2.4 x 2.4 x 1.8-m holding cages were located at 1 end of the aviary to maintain additional birds (Woronecki et al. 1988).

We used mist nets to capture redwings and starlings in July as they entered a nighttime roost along the shore of Lake Erie at Huron, Ohio. The roost has been present since at least 1983 and contained about 50,000 blackbirds and starlings in 1988. Redwings (males ≥ 1-year old) and starlings (mixed age and sex classes) were placed in separate holding cages at the aviary within 2 hours of capture and held there for 1 week to adjust to captivity.

Only birds in good physical condition (normal appearances and weight) were used; they were assigned randomly, 1 per test cage. Birds were provided grit (with vitamins and minerals), fresh water and a mixture of cracked corn, millet and sunflower seed, and poultry pellets (for starlings only). Birds were conditioned to testing procedures a week before the first test day by providing them fresh ears of worm-free corn on racks (to be described below) for several days.

Tests were scheduled 15 to 20 DAS for sweet corn and 21 to 28 DAS for field corn. This timing ensured that the earworm larvae were mature (20 to 38 mm in length) but still in the ear (before exiting to pupate) and it coincided with the milk-stage period of kernel maturation when most damage by redwings occurs (Bridgeland 1979, Dolbeer et al. 1984).

We started each test day at 0700 by picking a predetermined number of earworm-infested and insecticide-treated ears from the plants of a specific silking date. Each earworm-infested ear was slightly opened by carefully spreading the husk leaves apart to expose the cob tip to check for the presence and size of the worm (ears without worms were rejected). Husks were then closed and all selected ears were transported 7 km to the aviary.

Any insects were removed from the visible portions of the silks before the ears were randomly placed to position on wooden racks. Husks of insecticide-treated ears were opened and closed in the same manner as husks of earworm-infested ears. The wooden racks held ears with husks and shanks intact at an angle of 30° from the vertical, thus simulating the orientation as on the plants. Each rack held 2 or 4 ears spaced at 20-cm intervals to prevent birds from feeding on 1 ear while perched on an adjacent ear (Woronecki et al. 1988). Each bird in a cage was deprived of food for 2 hours before testing began, normally at 0900.

Aviary tests

Redwing damage to ears with and without opened husks (30-minute test).-To determine if slightly opening the husk (necessary to confirm presence of earworm) had any influence on bird feeding behavior, we compared damage between ears with opened husks and ears with husks left intact. Four uninfested ears of FC4 (2 ears opened and closed in the manner described above and 2 unopened) were placed in 12 test cages for 30 minutes after which the number of damaged kernels was recorded for each ear.

Redwing and starling feeding on ears with and without worms (30-minute test).-Tests with redwings were conducted on 9 dates between 10 and 31 August to compare feeding behavior and damage between ears with and without earworms. A maximum of 8 cages (replications) were used per test date. For sweet corn, either 2 or 4 ears of 1 cultivar (SC1 or SC2), 50% with and 50% without a corn earworm, were randomly assigned to position on a rack and placed in each cage for 30 minutes. For field corn, 2 hybrids, either FC2 and FC3 or FC8 and FC9, were tested simultaneously in the same cage (4 ears per cage, 2 ears from each hybrid, 1 with and 1 without a corn earworm). There were 76 replications using redwings, 44 with sweet corn and 32 with field corn. The same evaluations were done with starlings on 18 August (SC2, 4 replications) and 9 September (FC8, 8 replications). In each replication 4 ears were used, 2 with a worm and 2 without.

An observer using binoculars recorded feeding activity of the bird in each test cage for 30 minutes from a vehicle 8 to 10 m from the aviary. The 30-minute period was divided into 90 intervals of 20 seconds each which were chronicled using a tape recorder with numbered musical tones. Within each 20-second interval the bird was recorded as either directing or not directing a feeding response to each ear. A feeding response was defined as pecking or probing the corn husk or ear with the beak but excluded merely wiping the beak on the corn husk (Bernhardt et al. 1987). The interval at which the bird extracted the worm from an ear was also noted. Recording of feeding activity commenced within 30 seconds after racks were placed into test cages. At the end of the 30-minute period, racks were removed and the ears were examined. The numbers of kernels damaged by birds and by worms were recorded for each ear.

Bird damage in relation to frequency of ears with worms (3-hour test).-A test was conducted to determine if increasing the frequency of ears having corn earworms would increase the frequency of ears damaged by birds and the number of kernels eaten per ear by birds. Four treatment levels, each with 4 ears of FC9 placed on a rack, were used: (1) 4 ears each with a worm, (2) 2 ears with and 2 ears without a worm, (3) 1 ear with and 3 ears without a worm and (4) 4 ears without a worm. Racks were placed in cages, each with a single redwing, for 3 hours. Each treatment was replicated 9 times. The birds were not observed during the 3-hour test, after which each ear was removed and examined for presence of an earworm and the numbers of kernels damaged by birds and by worms.

Bird damage in field plots of corn

We monitored the corn plots at least weekly for bird damage by walking the rows and looking for signs of bird entry through the husk of ears. The number of ears either opened and damaged by birds or left undamaged in the earworm-infested, insecticide-treated, and control rows was counted.

RESULTS

Redwing damage to ears with and without opened husks

When opened and unopened ears free of earworms were presented to redwings, the percent of opened ears damaged (74%) was higher than that of unopened ears (29%) (X^2 = 14.31, 1 df, $P < 0.01$, N = 48 ears). Also the mean number of kernels eaten per opened ear (16.0) was greater than for unopened ears (3.7) (t = 3.66, 11 df, $P < 0.01$).

Redwing and starling feeding on ears with and without worms (30-minute test)

Overall, redwings located and ate 77% of the earworms during the 30-minute cage tests. Redwings directed 39% more feeding responses to the ears with worms than to the ears without worms (t = 3.11, 75 df, $P < 0.01$). However, the percent of ears damaged by birds and the mean damage (kernels eaten) per ear by birds were similar for ears with and without worms (X^2 = 0.02, 1 df, $P < 0.80$ for frequency of damage; t = 0.26, 75 df, $P = 0.80$ for kernels damaged). The total damage per ear (number of kernels eaten by birds and worms) was greater for ears with worms (31.4) than for ears without worms (12.6) (t = 6.31, 75 df, $P < 0.01$) (Table 1).

Results for starlings were similar to those for redwings. Overall, starlings located and ate 79% of the earworms during the 30-minute cage tests. Starlings directed 79% more feeding responses to the ears with worms than to the ears without worms (t = 2.72, 11 df, $P < 0.02$). However, the percent of ears damaged by birds and the mean damage (kernels eaten) per ear by birds were similar for ears with and without worms (X^2 = 1.37, 1 df, $P = 0.25$ for frequency of damage; t = 1.22, 11 df, $P = 0.30$ for kernels damaged). The total damage per ear (kernels eaten by birds and worms) was greater for ears with worms (59.7) than for ears without worms (11.3) (t = 6.29, 11 df, $P < 0.01$) (Table 1).

Bird damage in relation to frequency of ears with worms (3-hour test)

The proportion of ears damaged by redwings increased ($P < 0.03$) as the proportion of ears with worms increased; over 70% of the ears were damaged in the cages with either half or all of the ears with worms compared to 44% of the ears damaged in the cages with no worms (Table 2). However, the mean number of kernels damaged by birds per ear was similar (analysis of variance, F = 1.04, 3 and 32 df, $P > 0.10$) for the 4 levels of worm infestation as was the mean combined number of kernels damaged by birds and by worms per ear (F = 2.08, 3 and 32 df, $P > 0.10$) (Table 2).

When all treatment levels were pooled, redwings damaged a significantly ($P < 0.01$) greater percentage of ears with worms (79%) than without worms (49%). Birds located and ate the worm in 62 of the 63 ears with worms (98%) during the 3-hour tests. Although the mean bird damage per ear was similar for ears with and without worms, the mean combined damage by birds and worms was significantly ($P < 0.02$) higher for ears with worms compared to ears without worms (Table 2).

Table 1. Summary of 30-minute feeding behavior tests in which a male red-winged blackbird or a European starling was presented with 2 or 4 ears of corn, of which 1 or 2, respectively, had a corn earworm.

Species	No. of cages	Total ears tested[c]	Percent of worms eaten	Mean no. of feeding responses[a,b]			Percent of ears damaged by birds		Mean no. of kernels eaten/ear[a]				
									by bird		by bird+worm		
				worm ears		control ears	worm ears	control ears	worm ears	control ears	worm ears		control ears
Redwing	76	232	77	42.0	*	30.2	57	58	13.3	12.6	31.4	*	12.6
Starling	12	48	79	60.8	*	33.9	50	33	20.5	11.3	59.7	*	11.3

[a]Means with an asterisk between them are significantly ($\underline{P} < 0.05$) different, paired-difference t-test.
[b]The number of intervals out of 90 20-second intervals in which the bird fed upon the ear.
[c]50% of ears had worms, 50% served as no-worm, control ears.

Bird damage in field plots of corn

The only natural bird damage to field plots was on cultivar SC1. On 13 August, 20 days after 50% of the ears had silked, we noted bird damage in the 2 rows that had the ears infested with earworms 6 to 8 days earlier. Overall, 11% of the earworm-infested ears had been opened and damaged by birds which was significantly ($\underline{P} < 0.01$) higher than the 0% and 1% values for the ears in the adjacent 2 insecticide-treated and 2 control rows, respectively (Table 3) ($X^2 = 57.64$, 2 df). Natural infestation of insects was minimal; less than 1% of the ears in insecticide-treated and control rows had either corn earworms or European corn borers.

We did not observe birds feeding in the plot but suspect that the damage was by redwings and common grackles (Quiscalus quiscula). These species were frequently seen in other cornfields within 1 km of our plots during July and August (Okurut-Akol 1989).

DISCUSSION

The finding that redwings did more damage to ears whose husks had been opened than those left intact supports previous studies indicating that husk characteristics influence bird damage (Dolbeer et al. 1988). Although we only slightly spread apart the husk leaves down to the cob tip and then closed the husk as normal as possible, the birds could apparently detect and exploit these previous openings, perhaps reducing the energy expended to gain access to kernels.

Table. 2. Red-winged blackbird damage in relation to 4 frequency levels of corn earworm-infested ears using 1 bird and 4 ears per cage for 3 hours.

	Treatment Level (no. of ears with worm)				All treatments		
	4	2	1	0	Worm ears		Control ears
No. of replications	9	9	9	9			
Total no. of ears tested	36	36	36	36	63		81
Mean % of ears damaged/cage	72A[a]	78A	56AB	44B	79	*b	49
Mean no. of kernels damaged by birds/ear	22.5	27.7	24.5	21.3	27.8		21.0
Mean no. of kernels damaged by birds and worms/ear	29.4	30.6	25.7	21.3	34.1	*c	21.0

[a]Significant difference among treatment means ($F = 3.49$, 3 and 32 df, $\underline{P} < 0.03$); means separated by Duncan's Multiple Range Test ($\underline{P} < 0.05$).
[b]Significantly different ($X^2 = 13.59$, 1 df, $\underline{P} < 0.01$).
[c]Signficantly different ($t = 2.50$, 142 df, $\underline{P} < 0.02$).

Table 3. Number of ears opened and damaged by birds in the field for sweet corn cultivar SC1.

	Treatments		
	Earworm-infested rows	Insecticide-sprayed rows	Control rows
Total number of ears	429	311	271
Total number of ears opened	47	0	3

Both redwings and starlings directed more feeding responses toward ears with than without worms in the 30-minute tests, supporting the hypothesis that birds are attracted to corn ears containing insects. The birds found and consumed 77 to 79% of the worms in the 30-minute tests and 98% of the worms in the 3-hour tests. Although the proportion of ears opened and damaged by birds was similar for ears with and without worms in the 30-minute tests, a greater proportion of worm ears was damaged in both the 3-hour tests and the field observations. The increase in number of ears damaged in relation to the increase in number of ears with worms in the 3-hour tests was in agreement with the findings of Mott and Stone (1973). In their field study, when the incidence of earworms was low (about 10%), redwings fed mainly on corn and did not actively search for worms. When the incidence of worms was about 50%, redwings apparently searched for worms, resulting in a high incidence of ears being opened.

The finding that birds in the field selectively fed on rows of corn with a high incidence of earworms also suggested that birds actively search for insects in cornfields and are skilled at finding them. The sweet corn cultivar in which the damage occurred, SC1, had little husk coverage beyond the cob tip and had previously been shown susceptible to bird damage (Dolbeer et al. 1988). Perhaps the poor husk coverage allowed the birds to more readily find worms in this cultivar than in the other cultivars grown in the field. No bird damage was noted in the other cultivars.

Surprisingly, the amount of bird damage was not greater in worm-infested ears than in worm-free ears in either the 30-minute or 3-hour tests even though birds directed more feeding responses to worm-infested ears (30-minute tests) and damaged a greater proportion of worm-infested ears (3-hour tests) than worm-free ears. Thus, from the perspective of feeding responses, the results support our hypothesis that insects are attractive to birds, and their presence can increase bird damage to corn (Straub 1989, Dolbeer 1990). But from the perspective of actual corn removed by birds, this hypothesis was not supported (Bollinger and Caslick 1985a). None of the results were consistent with the hypothesis that insects in cornfields can substitute for corn in the diet, resulting in less bird damage to kernels (Mott and Stone 1973).

In conclusion, our findings indicate that earworms can influence feeding behavior by redwings and starlings on ears of corn. Although we did not measure an increase in kernels damaged on ears with worms compared to worm-free ears in aviary tests, we did measure increased feeding responses in the 30-minute tests and a greater proportion of ears damaged in the 3-hour tests and field test. We believe these findings are generally consistent with the hypothesis that by reducing insect populations in corn fields, one can make the fields less attractive to blackbirds and starlings. In addition, our study showed that redwings and starlings actively seek earworms in corn ears and at least have the potential for reducing populations of these insect pests in cornfields.

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