Effects of bird predation on some pest insect populations in corn

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Abstract

Intensive agriculture has led to a decrease in biodiversity in many areas of the world. Poisoning birds directly or eliminating habitats suitable for birds within an agricultural landscape, may remove potential control agents of insect pests. The main objective of this project was to investigate the effects of excluding avian species from portions of cornfields through the use of bird-proof netting. Although pest levels were low and exclusion nets failed to affect corn yield, some differences were seen in insect pest population levels, supporting the view that insectivorous birds play a beneficial role in corn fields. Cutworms (Agrotis spp.) and weevils (Sphenophorus spp.) were found at higher density in plots where birds were excluded, especially those situated near the field edge. Data on aphids (Rhopalosiphum maidis) and European corn borer (Ostrinia nubilalis) were more variable but tended in the same direction. Only the adult Northern corn rootworm (Diabrotica longicornis) population was clearly not reduced by birds but infestation levels were extremely low. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Birds; Farmland; Corn; Insect control; Cutworm; Weevil; European corn borer; Canada

1. Introduction

Few studies have been performed in North America to assess the effect of insectivorous bird species on insect numbers. Most of these studies have been carried out in forested habitats or rangeland. As recently reviewed by Kirk et al. (1996), studies performed in cornfields have dealt with specific pests and/or pest-bird species interactions; e.g. European corn borer and woodpeckers, Northern corn rootworm and red-winged blackbird. Aphids, weevils and cutworms are considered important pests of corn, but the effect of birds on their populations has not been studied. Most studies occurred near blackbird or crow roosts, leading to an atypically high bird density in the field. The present study investigated the effect of avian species through exclusion in two cornfields in the St. Lawrence lowlands ecoregion of Canada.

A secondary objective was to quantify bird visits to cornfields with respect to distance from the field edge and corn phenology, bird activity tending to be higher at the perimeter than in the center of the field (Best et al., 1990; Boutin et al., 1999).

A third objective was to evaluate whether birds were damaging corn during ear development. Such damage is often seen by growers as an impediment to creating bird-friendly habitats in proximity to cornfields.

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2. Materials and methods

2.1. Study area

The study was carried out on the Macdonald Campus farm of McGill University, on the island of Montréal during the 1997 and 1998 growing seasons. The two experimental fields (Fig. 1) were situated near the Morgan Arboretum, at Sainte-Anne-de-Bellevue (45°24'N, 73°56'W). Because of the proximity to a wooded area and raccoon (*Procyon lotor*) damage experienced in 1997, electric fences were erected around portions of the two experimental fields in 1998. Wires were installed at 10 and 20 cm above ground. To prevent weed contact with the fence, the herbicide glyphosate (*Round Up®*) was applied in a 50 cm band around the fence, twice during the summer. In 1998, mechanical weeding was performed by hand inside all plots to standardize treatments.

Grain corn (*Pioneer 3893®*) was planted in both fields. In 1997, corn was planted on 16 and 19 May, for the West and East field, respectively. In 1998, corn was planted on 11 May. Plantings were made at a density of 32,000 plants per acre, with space between rows of 0.75 m. The fields had been previously treated with pre-emergence herbicides. In 1997, *Frontier®* (Dimethenamid) and *Marksman®* (Potassium salt of dicamba 0.33 kg a.i./ha and Atrazine 0.55 kg a.i./ha) were applied in both fields and *Dual®* (Methochlor 1.73 kg a.i./ha) and *Field Start®* (Flumetsulam 0.0499 kg a.i./ha and Clopyralid 0.135 kg a.i./ha) were sprayed in 1998. Farmyard manure was also applied in the spring in both years.

3. Experimental design

The exclosure experiment, included a total of 36 plots (Fig. 1), 6 m × 7 m. Nets 3.6 m high with a mesh size of 2.5 cm² were used to exclude birds. Aluminum poles 3.9 m long and 3 cm in diameter, sunk 60 cm into the ground, were used to support the net. Shorter wooden poles (2.4 m) delimited control plots. Nets were applied for two different periods during the growing season. Twelve plots were covered year round, from June 1997 until October 1998, except for a few weeks to allow machinery to come in for planting, harvest and disking post harvest. Because of negative effects of some species of birds (e.g. blackbirds) on corn at specific periods of the growing season (Bendell et al., 1981), 12 plots (“early-uncovered”) excluded birds when ears were present, from the first week of August in 1997, and from the last week of July in 1998. The remaining 12 plots were uncovered controls where
birds had free access during the entire season. For some of the analyses, uncovered plots were combined with early-uncovered plots before they were covered. In the West field, the plots were placed along the eastern field edge mainly composed of mature coniferous trees, dominated by white spruce (Picea glauca). Plots in the East field bordered the Northern field edge mainly composed of staghorn sumac (Rhus typhina), black willows (Salix nigra) with an herbaceous cover containing mainly milkweed (Asclepias syriaca) and ragweed (Ambrosia artemisiifolia).

To assess the effect of distance from the field edge on bird visits to the cornfields and on insect populations, pairs of plots were used: one near the field edge (0–7 m), the other 18–25 m from it. A distance of 5 m separated each plot from the next laterally.

4. Sampling methods and statistical analysis

4.1. Insect sampling

Insect population densities or damage to plants were determined by visual inspection of 20 plants per plot chosen randomly in a stratified sampling plan. At least one plant was sampled per corn row, excluding the first and the last row to prevent edge effects. Inspection lasting 1–2 min per plant was made from the plant bottom to the top, the plant being disturbed as little as possible.

In 1997, four samplings were made, the first from 16 to 23 July, the second from 24 to 30 July, the third from 1 to 15 August, and the fourth from 18 August to 1 September. In 1998, a total of six sampling periods were used: 4 and 5 June, 17 and 18 June, 1 to 3 July, 13 to 15 July, 3 to 5 August, and 17 to 19 August.

For the European corn borer (Ostrinia nubilalis), a hole in the corn plant or a larva was recorded as a unit of infestation (Brunet, 1996). The nature of this measurement means that infestation scores were cumulative within a season. In mid-September in 1997 and at the end of August in 1998, a destructive sampling was made to detect damage by larval O. nubilalis. Number of cavities, height of cavities and number of larvae were also recorded. Ears were dried to 15% moisture and whole ears and kernels alone were weighed. For each plot, corn yield/ha was calculated using their respective plant density.

The corn leaf aphid (Rhopalosiphum maidis) population was visually estimated and the level of infestation classified using a score of 1–5 according to Foott (1977). Adult Northern corn rootworm (Diabrotica longicornis) found on the leaves and the silk were also counted visually. The number of corn leaves damaged by weevils (Sphenophorus spp.) was recorded in 1998 only. Adult weevils make a characteristic series of holes in leaves (Blatchley and Leng, 1916). This sampling was performed only once, during the 1–3 July sampling period, when the damage was easily recognized. After this period, leaves were physically damaged by hail, on 9 July.

Also, early in the spring of 1998, damage by cutworms (Agrotis spp.) was recorded on all corn seedlings inside each plot. A plant that had one or more leaves sharply cut was recorded as damaged by cutworms. This sampling was done twice weekly for 2 weeks: at the end of May and the beginning of June.

To assess the possible effect of nets on the populations of soil insect predators, and to ensure that insect predator population variability was not affecting pest populations, one pitfall trap was installed in each of 16 of the 36 plots. Half the traps were placed in covered plots, with the others in control plots with equal number near and far from the field edge. Glass jars 8.5 cm in diameter and 8.5 cm deep were sunk flush with the ground, and filled with 65 ml water and a drop of liquid soap. A plastic cover was installed 2 cm above ground level to prevent rain entering. Five samplings were done, on average every 2 weeks, on 7 June, 2 and 16 July, 6 and 20 August. Traps were emptied after 2 days, and the insects placed in 75% alcohol for identification to family.

For the insect and crop data, the experimental design was a randomized complete block design with six blocks, two treatments and a control, and paired observations. Soil type, shade and proximity to the road varied among plots. For example, soil type varied from sand to clay. Because of this high variability and the small number of insects encountered, differences
among treatment significant at the 10% level were considered significant. To stabilize the variance, arcsin transformations were applied for proportions and square root transformations for counts. Before arcsin transformation, the zeros were replaced by $1/4n$ and the 1 by $(n - 1/4)/n$, where $n$ represents the number of observations (Snedecor and Cochran, 1989). The sum and the difference between paired plots were used for an analysis of variance using SAS. Also, modified analyses of variance were performed on repeated measures for each year separately.

4.2. Bird observations

Birds were observed in and between uncovered plots situated in front of the elevated blinds located at the edge of the two cornfields. Blinds were 4.9 m high and allowed the observer to see above the full-grown corn plants.

Because of the high density of corn plants, it was not always possible to observe bird activity inside the fields. To estimate the frequency and the duration of bird visits, all bird arrivals and departures were recorded as recommended by Fletcher and Greig-Smith (1988). Observation periods were divided into intervals of 3 min, to estimate the average time spent by a bird in the field. Distance from the field edge was also recorded for all entries and exits (0–7, 7–18, 18–25, 25–50 m). The numbers of visits were adjusted for the surface area under observation. Periods of observation varied between 45 and 60 min at sunrise or sunset. The observer waited 15 min before starting the observation period to minimize the disruption effect of the observer’s arrival.

In 1997, there were only 25 periods of observation and no analysis was performed because of insufficient data. For the 1998 data, a simple regression of visit frequency (visits/ha) by distance from field edge was calculated using a distribution-free re-randomization test (Edgington, 1986; Sokal and Rohlf, 1995), using the Rerand2 program (Collins, 1998). Data were randomly rearranged 1000 times and these results constitute the reference set for determining significance. When a trend was significant, the distance interval with the highest visit score was discarded and the analysis was run again with the remaining data. The analysis was repeated for three periods, according to corn phenology: before seeding (From 6 April to 11 May), vegetative stage (from 17 May to 14 July) and reproductive stage (from 16 July to 13 October).

5. Results

5.1. European corn borer

During the 2 years of the study, less than one European corn borer per plant was recorded on average (Table 1). In 1998, *O. nubilalis* infestation was even lower than in 1997, perhaps because of the dry summer. On 16 July of 1997, the average number of *O. nubilalis* per plant was nevertheless significantly lower ($P = 0.006$) in early-uncovered plots compared with control plots and, on 1 August 1997, the number of borer larvae was significantly higher in covered plots compared with the combined treatments where birds had free access ($P = 0.069$).

In 1998, borer larvae did not appear in sufficient numbers to allow for statistical analysis until the fifth sampling period, in early August. In June, only 0.5% of all plants were infested, whereas just 3% were infested in July. On 3 August 1998, early-uncovered plots (having been covered for a few days only) were more infested than covered plots ($P = 0.031$). The number of larvae did not differ among treatments on 17 August but on 23 August, more larvae were found in covered plots than in uncovered plots ($P = 0.024$). Looking at the three sampling periods in August, the data suggest that the *O. nubilalis* population increased in covered plots but remained stable in the other plots. However, on 25 September there was no difference among the three treatments and a higher variability was observed.

At the end of August 1998, the number of *O. nubilalis* larvae in galleries was significantly higher in covered plots than in the other plots (77% occupancy compared with 40% in both uncovered and early-uncovered plots ($P < 0.08$ for both comparisons)).

5.2. Corn leaf aphids

In 1997, corn leaf aphid infestation showed significantly different trends over time between covered plots and the others ($P = 0.028$ for time by treatment interaction, Fig. 2). In covered plots, aphid populations
Table 1
Average number of *O. nubilalis* per plant for three treatments and 2 years of study

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Covered plots</th>
<th>Early-uncovered plots</th>
<th>Uncovered plots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td>1997</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 July</td>
<td>0.66</td>
<td>a</td>
<td>0.29</td>
</tr>
<tr>
<td>24 July</td>
<td>0.63</td>
<td>c</td>
<td>0.41</td>
</tr>
<tr>
<td>1 August</td>
<td>0.66</td>
<td>d</td>
<td>0.37</td>
</tr>
<tr>
<td>18 August</td>
<td>1.2 f</td>
<td>0.53</td>
<td>0.91</td>
</tr>
<tr>
<td>9 September</td>
<td>0.62</td>
<td>g</td>
<td>0.62</td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 June</td>
<td>0</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td>17 June</td>
<td>0.017</td>
<td>–</td>
<td>0.004</td>
</tr>
<tr>
<td>1 July</td>
<td>0.063</td>
<td>–</td>
<td>0.004</td>
</tr>
<tr>
<td>13 July</td>
<td>0.021</td>
<td>–</td>
<td>0.021</td>
</tr>
<tr>
<td>3 August</td>
<td>0.09</td>
<td>h</td>
<td>0.21</td>
</tr>
<tr>
<td>17 August</td>
<td>0.27</td>
<td>j</td>
<td>0.26</td>
</tr>
<tr>
<td>23 August</td>
<td>0.40</td>
<td>k</td>
<td>0.23</td>
</tr>
<tr>
<td>25 September</td>
<td>0.28</td>
<td>m</td>
<td>0.40</td>
</tr>
</tbody>
</table>

* Data in italic refer to sampling periods when not enough insects were sampled to allow statistical analysis. For each sampling date, means followed by the same letter are not significantly different according to Duncan’s Multiple Range test.

5.3. Northern corn rootworm

Northern corn rootworms were recorded in sufficient numbers for analysis in 1997 only. During the...
last sampling period of 1997, fewer adult *D. longicornis* were found in covered plots than in the others ($P = 0.042$). No other difference was recorded.

### 5.4. Weevils

Weevil damage was recorded during one sampling period, on 1 July. Covered plots near the field edge had significantly higher levels of damage than plots near the field edge to which birds had access ($P = 0.02$) (Fig. 4). The difference between treatments according to distance from the field edge was also significant ($P = 0.025$).

### 5.5. Cutworm

In the last two of the four sampling periods of 1998, damage to corn seedlings by cutworm was significantly higher in covered plots. On 28 May, cutworms had damaged 15% of the covered plants, 11% only where birds had access ($P = 0.064$). The same trend was observed on 2 June: 14% of the covered plants bore signs of damage compared with 11% in the unprotected plots ($P = 0.073$).

Splitting the data into near and far plots shows that this trend was restricted to plots nearer to the field edge (Fig. 5). On 28 May and 2 June, an estimated 18% of covered plants in near plots had been damaged by cutworms compared with 11% in plots to which birds had access ($P < 0.05$). A modified analysis of variance on repeated measures on plots near the field edges showed a significant time by treatment effect ($P = 0.064$). The percentage of plants damaged by cutworms in plots where birds had free access stayed stable over time whereas it increased in plots where birds were excluded. The trend over time for plots near and far was significantly different ($P = 0.018$) and more plants were damaged near the edge of the fields.

### 5.6. Arthropod soil predators

Fig. 6 shows the numbers of individuals found in pitfall traps from the four main predator groups. An analysis of variance did not detect any difference among treatments.

### 5.7. Corn growth and yield

Nets had no significant effect on any of the measurements: plant density, plant height, ear height or length, and dry weight of the grains.

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Fig. 4. Proportion of leaves damaged by weevils on 1 July 1998.

Fig. 5. Proportion of plants damaged by cutworms over the sampling period in plots located near the field edges.

Fig. 6. Number of insects in each soil insect predator group caught in pitfall traps.
Table 2
Bird species observed inside cornfields during observation periods of 1998

<table>
<thead>
<tr>
<th>Rank</th>
<th>Species</th>
<th>Guild</th>
<th>Number of bird visits/ha/h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>West field</td>
<td>East field</td>
</tr>
<tr>
<td>1</td>
<td>Red-winged blackbird</td>
<td>Omnivore ground</td>
<td>22.09</td>
</tr>
<tr>
<td>2</td>
<td>Sparrows (song sparrow and chipping sparrow)</td>
<td>Omnivore ground</td>
<td>27.63</td>
</tr>
<tr>
<td>3</td>
<td>American robin</td>
<td>Omnivores lower canopy/vermivore</td>
<td>5.85</td>
</tr>
<tr>
<td>4</td>
<td>European starling</td>
<td>Omnivore ground</td>
<td>4.60</td>
</tr>
<tr>
<td>5</td>
<td>Feral pigeon</td>
<td>Omnivore ground</td>
<td>0.00</td>
</tr>
<tr>
<td>6</td>
<td>Warblers</td>
<td>Insectivore</td>
<td>5.89</td>
</tr>
<tr>
<td>7</td>
<td>Dark-eyed junco</td>
<td>Omnivore ground</td>
<td>4.08</td>
</tr>
<tr>
<td>8</td>
<td>Brown-headed cowbird</td>
<td>Omnivore ground</td>
<td>0.92</td>
</tr>
<tr>
<td>9</td>
<td>American goldfinch</td>
<td>Omnivores lower canopy</td>
<td>1.59</td>
</tr>
<tr>
<td>10</td>
<td>American crow</td>
<td>Omnivore ground</td>
<td>0.97</td>
</tr>
<tr>
<td>11</td>
<td>Mourning dove</td>
<td>Herbivore/granivore</td>
<td>1.69</td>
</tr>
<tr>
<td>12</td>
<td>Ring-billed gull</td>
<td>Insectivore</td>
<td>2.06</td>
</tr>
<tr>
<td>13</td>
<td>Eastern kingbird</td>
<td>Insectivore</td>
<td>0.58</td>
</tr>
<tr>
<td>14</td>
<td>Indigo bunting</td>
<td>Omnivores lower canopy</td>
<td>0.00</td>
</tr>
<tr>
<td>15</td>
<td>Common grackle</td>
<td>Omnivore ground</td>
<td>0.56</td>
</tr>
<tr>
<td>16</td>
<td>Killdeer</td>
<td>Insectivore</td>
<td>0.12</td>
</tr>
<tr>
<td>17</td>
<td>Mallard</td>
<td>Herbivore/granivore</td>
<td>0.00</td>
</tr>
<tr>
<td>18</td>
<td>Canada goose</td>
<td>Herbivore/granivore</td>
<td>0.08</td>
</tr>
<tr>
<td>19</td>
<td>Wood duck</td>
<td>Herbivore/granivore</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Total number of bird visits

78.79  57.49  136.28

Species are enumerated in order of importance, according to the number of visits/ha/h in the two fields.

5.8. Birds

A total of 20 bird species was observed in the fields during the 90 observation periods of 1998 (Table 2). Other bird species were seen inside the fields but not during observation periods. A Northern flicker (Colaptes auratus) was trapped inside a covered plot on 29 June and a ruby-throated hummingbird (Archilochus colubris) was seen feeding on milkweed flowers on 7 July. Barn and tree swallows (Hirundo rustica and Tachycineta bicolor) were often observed flying over the fields but were not recorded because they never landed.

For the largest feeding guild present on the study area — the ground feeding omnivores — the two fields showed very different patterns (Fig. 7). In the West field, birds tended to stay closer to the coniferous edge before corn seeding as well as during the vegetative stage. This trend was reversed during the corn reproductive stage (significant crop phenology by distance interaction, \( P < 0.025 \)). Early in the summer, mainly red-winged blackbirds (Agelaius phoeniceus) and American robins (Turdus migratorius) were observed in the fields whereas mainly song and chipping sparrows (Melospiza melodia, Spizella Fig. 7. Number of visits/ha/h for ground-feeding omnivorous birds grouped by distance from the field edge, for three periods during the growing season and in the two fields.)
passerina) were seen entering the field as the corn matured.

In the East field, along the herbaceous edge, the number of bird visits did not vary by distance into the field at any period of the corn growing season. Most birds, however, came not from the herbaceous edge but from the North-East side of the field, where mature trees were present.

6. Discussion

The data on the European corn borer were highly variable. Where differences occurred among treatments, there was a tendency to higher pest levels in covered plots. In August 1998, for instance, the number of occupied tunnels was significantly higher in covered plots. Birds known to feed on borer larvae, like red-winged blackbirds and American crows (Corvus brachyrhynchos), were present in the field early during the growing season. In the first year of the study, nests where still not installed during this period thus minimizing the ability to see differences. At the end of the summer, mainly sparrows were seen in the field and they are not able to reach the borer larvae that are hidden inside corn stems.

Infestation scores for corn-leaf aphids were also variable but again, covered plots had the higher infestation levels. Many bird species observed in the fields in July and August are known to feed on aphids, including indigo bunting (Passerina cyanea) (Audubon, 1997), American goldfinch (Carduelis tristis) (Mid- delton, 1993), and chipping sparrow (Knowlton and Harmston, 1941).

The data on the proportion of plants damaged by both cutworms and weevils in the early growing season suggest that birds did have a protective role, in plots situated near the field edge. According to Newstead (1908), based on stomach content analysis, British insect-eating birds prefer weevils to any other group of insects. Chipping sparrow (Knowlton and Harmston, 1941), American robin, indigo bunting, brown-headed cowbird (Molothrus ater), killdeer (Charadrius vociferus) (Audubon, 1997) and Common Grackle (Quiscalus quiscula) (Forbes, 1883) are all possible candidates on the study fields. American robins were most frequently foraging near the field edge (38% of total visits before seeding), where the larger difference between treatments was recorded.

Cutworms were potentially the most important pest species in the study fields and damage in covered plots near the field edge was almost twice as high as the damage sustained in open plots. Some of the species mentioned in the literature as feeding on cutworms were observed, e.g. killdeer (Rockwood, 1925), song sparrow (Forbush, 1913; Audubon, 1997), and American robin (Forbes, 1883, 1903), the young of which may eat almost twice their weight of cutworms per day (Hewitt, 1921). American robins were seen in the fields early in the summer, when cutworms were available on and near the soil surface.

The Northern corn rootworm was the only pest species found in slightly higher numbers in covered plots. This was not expected because birds are well known as predators of this pest. Bollinger and Caslick (1985) showed that the number of red-winged blackbirds visiting a corn field was strongly correlated with the number of adult rootworms present on corn plants ($r = 0.61, P < 0.0001$). However, infestation levels in the present study were extremely low, not exceeding one beetle per plant.

Despite the above-noted differences in some insect pest levels among treatments, there was no measurable difference in corn growth or yield. However, in both years of the study, insect pest populations in the two fields under study were low, far below any damage thresholds. Both cultural practices and environmental conditions may have been responsible for the presence of so few insects. No bird damage was detected in the present study.

Small plot exclosure studies suffer from a number of potential limitations and biases. Because the exclosures in the present study were permeable to pest movements, differences between covered and uncovered plots tended to be minimized in the case of mobile pest species such as adult corn rootworm. Also, bird exclosures may lead to increased numbers of insect predators such as ants, thereby making it more difficult to document any direct effect of the birds on pest species. Because the density of arthropod soil predators did not appear to be affected by the exclosures in the present study, this potential confounding effect of the nets was probably minimal. However, the use of pitfalls cannot be considered adequate to census all predator species. Failure to detect differences in corn
growth and yield among treatments demonstrated that the nets themselves did not interfere with the crop. Growth interference was not expected because even smaller mesh sizes have been found to have minimal influence on plant growing conditions (Gardner and Thompson, 1998).

7. Conclusion

Differences in infestation levels obtained among treatments were generally small and pest levels very low. It is, therefore, not surprising that the present study failed to document any effect of bird exclosures on corn growth and yield. Nevertheless, the results presented suggest that both cutworm and weevil populations were reduced by the presence of birds, especially near the field edge. Given the biases associated with small exclosure studies, all of which tend to obscure among-treatment differences, these results can be considered significant. The American robin was probably responsible for this difference because it was the principal bird species observed in the fields when these insects were available. The data were insufficient to unequivocally document an effect of bird predation on aphid and European corn borer numbers but the positive results warrant further research.

The data suggest that more work is required to better understand the use of farm fields by birds, especially in relation to the type of field edge and the phenology of the crop. A more sympathetic management of agroecosystems has been advocated to aid in the conservation of declining farmland bird species (Mineau and McLaughlin, 1996). It would clearly be easier to convince corn farmers to adopt such management practices if they were economically advantageous.

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