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RESPONSES OF PEST BIRDS TO REFLECTING TAPE IN AGRICULTURE

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Bird damage to agriculture occurs throughout the world and involves many of the same crops and genera of birds (De Grazio 1978). Numerous devices have been used to scare or repel birds from crops. In developing countries, these include such traditional techniques as drums, gourd or can rattles, whips, plastic and cloth streamers, and flags (Ruelle and Bruggers 1982). In developed countries, more expensive and sophisticated methods are used, including auditory devices such as distress calls, exploders, or noise bombs (Mott 1980, Wright 1982), and visual devices such as flashing lights, scarecrows, helium-filled balloons (Kalmbach 1945), model hawks (Hothem and DeHaven 1982), wires, or monofilament line (Amling 1980, Blokpoel and Tessier 1983, Laidlaw et al. 1984). Visual and auditory techniques to scare birds often are effective for only a short time before birds habituate to them. Because such scaring devices usually are relatively inexpensive (particularly traditional ones), safe, simple to use, and generally obtainable (the requirements necessary for use in developing countries), promising new devices should be evaluated as they become available.

We evaluated the effectiveness of Bird-Scaring Reflecting Tape®[1], a material fabricated and marketed in Japan. This tape is an elastic, transparent, synthetic resin film to which a silver metal layer is applied by vapor deposition, then coated with a colored synthetic resin (in this case red). Other colors also are available. The 3-layer tape is 0.025 mm thick, 11 mm wide, and sold in 82- or 100-m rolls. The tape reflects sunlight to produce a flashing effect and, when stretched, it pulsates and produces a loud, humming, or sometimes thunder-like noise in the wind (Fig. 1). In Japan it is called "Boh-choh" or "Tori-oi" tape and is popular with farmers to protect rice fields from Java sparrows (*Padda oryzivora*). However, it has not been systematically evaluated on Java sparrows in Japan (K. Nakamura, Natl. Res. Center, Japan, pers. commun.), or on other pest birds in the few countries—Kenya, Thailand, and Saudi Arabia—where it apparently also is used. This tape is manufactured by several companies in Tokyo, Japan, including Yamani-Sangyoh Co., Ltd., 1–28, Saikudani 1-chome, Ten'nohji-Ku,

[1] Reference to trade names does not imply U.S. Government endorsement.

Fig. 1. Bird-Scaring Reflecting Tape® installed above a sunflower field in Bangladesh.

Osaka, Japan, and distributed by several others, including Maruzen Trading Co., Ltd., % Fuji-Bldg. 39-2, Ueshio-Cho, 2-chome, Minami-Ku, Osaka, Japan, and Nishizawa Ltd., Tokyo Branch, 12-5, Kodenmacho Nihonbashi, Chuo-Ku, Tokyo, Japan (K. Hashimoto, Nishizawa, Ltd., and K. Nakamura, pers. commun.).

METHODS

Trials were conducted between March 1984 and March 1985 at agricultural research stations in Bangladesh, the Phillippines, and India and at national wildlife refuges in the United States.

Bangladesh

On 30 March 1984, we installed reflecting tape over a 1,200-m^2 sunflower plot that was being heavily damaged by rose-ringed parakeets (*Psitticula krameri*) at the Regional Agricultural Research Station (RARS), Jessore. The tape was tied to the tallest heads at both ends and in the middle of the 40-m long plot at 5-m intervals perpendicular to the prevailing wind direction. The tape was stretched relatively tightly and slightly twisted, causing it to produce pulsating reflections and humming sounds. Damage was evaluated on all sunflower heads in the field at the beginning and end of the trial using a plastic template (Dolbeer 1975). Birds were counted as they were flushed from the field at 30- or 60-min intervals from 0600 to 1800 on 29 and 30 March, before the tape was installed and for 15 days postinstallation.

We also initiated a concurrent trial in 2 plots of foxtail millet being damaged by 100–200 munias (*Lonchura* spp.). The millet plots were separated by a 20-m-wide strip of barley. Reflecting tape was installed over Plot 1 (900 m^2) just above the crop at 5-m intervals on 30 March; on 3 April 1984, it was removed and installed over Plot 2 (700 m^2). On 8 April, tape was reinstalled over Plot 1 so that both plots had tape for an additional 4 days. Between 10 and 15 bird counts were made daily from 0600 to 1800 during the 15-day trial.

In the third trial at Jessore (April 1984) reflecting tape was tested over 1 of 2 plots of corn (maize) being damaged by parakeets. The 2 plots were 0.28 ha (with tape) and 0.08 ha (without tape), 32 m apart, and in the same maturation stage. On 16 April 1984, the tape was installed at 5-m intervals in parallel rows by attaching it to the tips of stalks. Bird counts were made 10 times daily (0600-1800) for 15 days after installing the tape.

At the Bangladesh Agricultural Research Institute (BARI), Joydebpur, tape was evaluated between 9 and 29 May over corn that was being attacked by jungle crows (*Corvus macrorhynchos*) as they returned to their night roost. One 0.5-ha plot was protected with reflecting tape installed on 10 May 1984 in parallel rows, 4 m apart, and another 0.10-ha plot was unprotected. Plots were about 150 m apart. Damage was assessed in each plot on 14 May 1984 by counting damaged and undamaged ears in the taped plot and all ears in 25% of the rows in the untaped plot. At harvest (29 May 1984), all damaged and undamaged ears in both plots were counted. Bird counts were made at 30-min intervals from 1530 to 1800 daily from 9 May 1984, 6 days before installing the tape, until harvest.

Philippines

Two trials were conducted to protect ripening sorghum from European tree sparrows (*Passer montanus*) and munias at fields provided by the University of Philippines at Los Banos (UPLB) at the International Rice Research Institute (IRRI). In the first trial, reflecting tape was suspended from 2.5-m poles placed at 5-m intervals in 400 m^2 of a 1-ha field on 9 April 1984. Bird counts were made at 30- or 60-min intervals at random time periods for 2 days pre-installation and 6 days postinstallation.

In the second trial, reflecting tape was installed over 1 of 2 0.08-ha plots of ripening sorghum, separated by a 3-m-wide unplanted band. Bird counts were made at random time periods for 14 days before installing the tapes on 24 April 1984 and for 9 days afterwards. The tape was first installed at 7-m intervals, then after 3 days installed at 5-m intervals until the end of the trial on 3 May. Bird damage was visually estimated on 87–100 randomly selected sorghum heads in each plot when the tape was first installed and again at the end of the study. Wind velocity was recorded with a portable, hand-held Dwyer wind meter during each bird count.

India

Trials were conducted to protect sunflowers from rose-ringed parakeets at the Agricultural Research In-

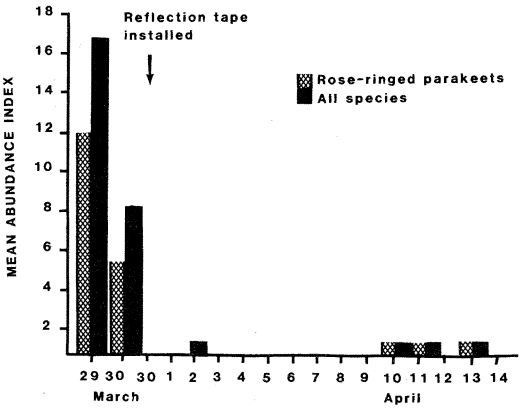

Fig. 2. Average number of birds counted at 30- or 60-min intervals (n = 10–14/day) in a 1,200-m^2 sunflower plot before and after installing Bird-Scaring Reflecting Tape® over the entire plot at noon on 30 March 1984 at Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Jessore, Bangladesh.

stitute, Rajendranager (Hyderabad), during November and December 1984, and sweet corn from parakeets and house crows (*C. splendens*) at the Agricultural Research Station, Amberpet (Hyderabad) during February–March 1985. At Rajendranager, 7 25-m strips of tape were installed on 22 November 1984 in parallel rows at 3-m intervals above the 20 × 25-m sunflower plot; tape was removed on 14 December 1984. At Amberpet, 3 7-m strips of tape were similarly installed on 22 February 1985 above the 10 × 20-m sweet corn plot; tape was removed on 6 March 1985. At each station, 1 plot identical in size to the taped plot and ≥30 m away was left untaped. Both crops were in early maturation stage and free of bird damage when the tape was installed. Both plots at each trial site were harvested when the tape was removed to determine yield. Bird counts were made daily for ≥7 days after installing the tape.

United States

Trials were conducted to protect ripening corn from red-winged blackbirds (*Agelaius phoeniceus*) and yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) at Sand Lake National Wildlife Refuge (SLNWR) in South Dakota, ripening finger millet from red-winged blackbirds at Ottawa National Wildlife Refuge (ONWR), Lucas County, Ohio, and sunflowers from American goldfinches (*Carduelis tristis*) in Erie County, Ohio.

At SLNWR, 13 strips (100 m each) of reflecting tape were suspended on 4-m poles (7 cm diam) in a 1.3-ha section of a 6.8-ha field on 26 August 1984. The trial plot was adjacent to a marsh and bordered by trees. Eleven 100-m strands of tape were placed in parallel rows at 10-m intervals in the field perpendicular to the marsh. Two strands were placed along the field's border adjacent to the roost. Under maximum wind velocity of 32 km/hour, the tape bowed about 5 m and rose and fell 3 m. Damage (De Grazio et al. 1969) was assessed on 1.8-m^2 plots at 28 randomly selected locations in the field on 23 August, before the tape was installed, at the time it was installed, and 3, 6, 10, and 15 days after it was installed. Birds were counted several times daily from 23 August 1984 until the end of the trial on 10 September 1984.

At ONWR, tape was installed on 21 August 1984 over 1 1,500-m^2 plot (Plot B) in a 6,500-m^2 field of millet in the milk and early maturation growth stages. Two other plots (1,500 m^2 each; Plots C and D) were left untaped. All plots were separated and bordered by 500-m^2 buffer areas. Three 150-m-long, parallel rows of tape were suspended from poles at 5-m intervals, perpendicular to wind direction, about 30 cm above the crop on Plot B. Plots with and without tape were demarcated by yellow flagging. The millet field was bordered by sunflowers, sweet corn, trees, and shrubs on all 4 sides. At 2- to 4-day intervals, birds entering and leaving plots were counted at 5-min intervals for 2–3 hours between 1630 and 1930 on 2 days before treatment and 7 days after treatment. The average weight (g) of damaged and undamaged panicles was determined before and after installation by collecting 3 millet heads every 5 m along a diagonal transect through each plot (75 heads/plot). Twenty of these 75 heads/plot also were scored as damaged or undamaged (incidence) and visually classed into damage categories 0–25, 26–50, 51–75, and 76–100%.

In Erie County, Ohio, 3 sunflower varieties were planted in a 0.4-ha field on 8 July. On 24 August 1984, 9–14 days before the varieties flowered, 28-m-long strips of reflecting tape were suspended above sunflower rows from 2.1-m poles at 4.6-m intervals in a 0.17-ha area of the 0.4-ha field. The taped plot was separated by a 26-m buffer zone from a similar-sized, untaped plot. All 3 varieties were in each plot. The plots were visited at least 3 times weekly between 2 September 1984 and 2 November 1984 to count birds and repair broken, tangled, or loose strands of tape. On 26 October 1984 and 2 November 1984, bird damage was estimated (Dolbeer 1975) on heads of 40 randomly selected plants from the center of each variety in the taped and untaped ends of the field.

RESULTS AND DISCUSSION

Bangladesh

Rose-ringed parakeets had eaten 23% of all sunflower seeds in the trial plot at Jessore at the time reflecting tape was installed on 30 March. Before the tape was installed, an average of 12 rose-ringed parakeets and 6 house sparrows (*P. domesticus*) fed/observation.

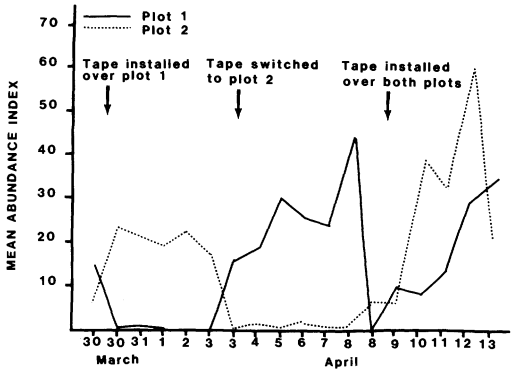

Fig. 3. Average number of munias counted at 30- or 60-min intervals (n = 6–14/day) in 2 foxtail millet plots before and after installing Bird-Scaring Reflecting Tape® over Plot 1 on 30 March 1984. Tape was removed and installed over Plot 2 at noon on 3 April, and both plots were taped on 8 April. Study was conducted at Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Jessore, Bangladesh.

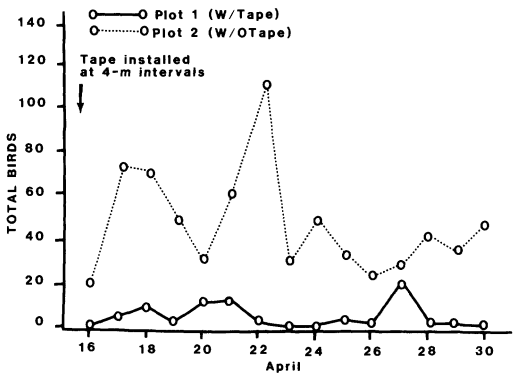

Fig. 4. Total number of birds counted 10 times daily (1-hour intervals) in 2 corn plots at Bangladesh Agricultural Research Institute, Jessore, Bangladesh, during April 1984. Bird-Scaring Reflecting Tape® was installed at 4-m intervals above Plot 1; Plot 2 was left untaped.

Birds fed regularly throughout the day but numbers peaked during early morning and late afternoon. For 15 days after the tape was installed, virtually no parakeets entered the plot (Fig. 2), and no additional damage occurred. Several sparrows occasionally re-entered the plot, flying in beneath the ribbon to feed on seed on the ground. A flock of 18–25 parakeets remained in the area, loafing in palms surrounding the sunflowers. Although they often approached the sunflowers, they always returned to the palms, then fed in wheat stubble in an adjacent field. This effect was striking because parakeets generally are difficult to repel from sunflowers, especially after they establish feeding patterns.

In the trial to repel a resident population of 100–200 munias from plots of foxtail millet, the reflecting tape caused birds to move between taped and untaped plots (Fig. 3). Birds switched plots almost immediately each time the tape was moved. The morning the trial began (30 March), an average of 15 birds/count were feeding in Plot 1. For 4 days after the tape was installed, no birds fed in the plot, but 20 to 24 birds/count fed in Plot 2. At noon on 3 April when the tapes were switched to Plot 2, munias immediately began feeding in Plot 1. However, on 8 April when both plots were covered with tapes, munias fed in both plots, reaching a peak of 60 birds/count in Plot 2 and 35 birds/count in Plot 1. These results suggest that reflecting tape can repel munias from individual millet fields if an alternative food is available.

In the third trial at Jessore, parakeets avoided a taped corn plot and fed elsewhere. A total of 8 parakeets and 70 other birds (Indian mynas [*Acridotheres tristis*] and house sparrows) were counted during 150 observations during 15 days in the plot with tape; 111 parakeets

Table 1. Jungle crow damage to ripening corn before and after installing Bird-Scaring Reflecting Tape®, Bangladesh Agricultural Research Institute, Joydebpur, May 1984.

Damage or use	Taped	Untaped
Percent damage[a]		
Pre-installation	12.7 (1,649)	3.2 (3,847)
Postinstallation	18.0 (423)	13.1 (2,223)
Mean birds/count[b]		
Pre-installation	13 (36)	32 (36)
Postinstallation	2 (60)	15 (60)

[a] Number of ears examined is given in parentheses.
[b] Number of counts is given in parentheses.

and 507 other birds were counted in the untaped plot during the same time period (Fig. 4).

Reflecting tape reduced damage to corn by jungle crows at BARI, Joydebpur (Table 1). An additional 5.3% damage occurred in the plot after tape was installed compared to 9.9% additional damage in the untaped plot. The mean number of birds counted in the taped plot decreased 83% from pre-installation counts; the decrease was 53% in the untaped plot.

Philippines

The results of the initial trial in the 400-m^2 sorghum plot were encouraging. On 10 April, the day before the tape was installed, an average of 17 birds/count (15 tree sparrows and 2 munias) was observed in the plot. After the tape was installed, both species immediately discontinued feeding and avoided the area for 8 days until the trial ended.

In the second trial, damage to sorghum increased 0.5% (15.9% to 16.4%) in the taped plot and 1.5% (17.6% to 19.1%) in the untaped plot. Bird numbers in the taped plot again immediately decreased from highs of about 35/count (75% tree sparrows) when tape was installed to <8/count for 4 days. The numbers of birds gradually increased to a high of 27/count (97% munias). Although munias and tree sparrows fed in mixed flocks initially, this pattern ended after the tape was installed. Tree sparrows approaching the taped plot from above abruptly changed direction and landed on wires or a road; those approaching low immediately rose and veered away in another direction. Munias gradually re-entered the taped plot from the adjacent untaped plot, and once several birds began feeding on the edge of the taped plot, others joined them. Reducing the tape interval from 7 m to 5 m did not seem to alter the feeding pattern of munias.

Weather conditions may possibly explain the apparent ineffectiveness of the tape on munias in this trial (when alternative food was available in an untaped plot) compared to its effectiveness on munias in the millet trial at Jessore, Bangladesh. During the 8 days before installing the tape, wind velocity averaged 4.8 km/hour. During the first 3 days after installing the tape when both species avoided the field, the wind velocity also was high, averaging 6.3 km/hour. However, during the subsequent 9 days, when munias returned, wind velocity averaged only 2.3 km/hour. Likewise, the weather was sunny and hot (>32 C) on 10 of the first 11 days of the study, whereas from 26 April to 2 May, when munias returned, it was cloudy and rainy with the onset of the monsoon season. In comparison, in Bangladesh, every day during the trial was hot (>35 C) and sunny.

Table 2. Yield and bird damage to sunflower and sweet corn in plots with and without Bird-Scaring Reflecting Tape® at agricultural research stations in India during 1984[a] and 1985.[b]

Crop	Damage incidence[c] (%)	Yield (kg/ha)
Sunflower		
Taped	<5	860
Untaped	27	562
Sweet corn		
Taped	11	2,170
Untaped	77	1,340

[a] Rajendranagar, November 1984. Taped and untaped plots were each 500 m^2.
[b] Amberpet, February 1985. Taped and untaped plots were each 200 m^2.
[c] Incidence is based on ratio of damaged to total heads sampled.

India

In the sunflower trial at Rajendranager, flocks totaling about 150 parakeets were being scared daily from the trial plots by guards before the tape was installed. Once the tape was installed, human bird scaring was discontinued. Although a flock of 10–15 parakeets was occasionally seen in the vicinity of the taped plot, birds did not feed on sunflowers. Instead, parakeets fed in the untaped plot, resulting in

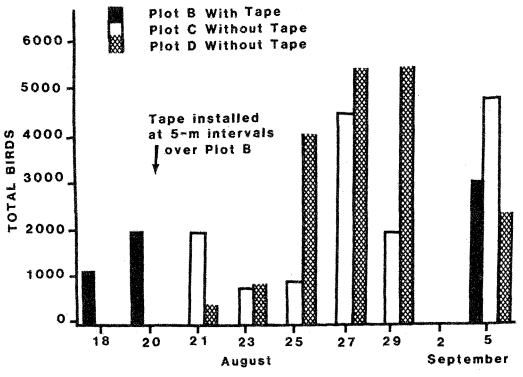

Fig. 5. Total number of red-winged blackbirds counted at 15 5-min intervals entering and leaving 1,500-m^2 plots of millet at Ottawa National Wildlife Refuge, Lucas County, Ohio, before and after installing Bird-Scaring Reflecting Tape® over Plot B on 20 August 1984.

a 298 kg/ha greater yield in the taped plot (Table 2). Comparable results were achieved at Amberpet, where almost 4 times more birds were observed in the untaped plot (91 birds [91% rose-ringed parakeets]) than in the taped plot (24 birds [70% rose-ringed parakeets]) during the 7 days postinstallation. Likewise, the extrapolated yield of sweet corn from the 200-m^2 trial plots was 830 kg/ha greater in the taped than the untaped plot.

United States

Sand Lake National Wildlife Refuge.—Blackbird damage to corn averaged 101 kg/ha per day for a 3-day period before installing the tape (23–25 August), but only 12 kg/ha per day during a 3-day period after installing the tape (26–28 August), an 88% decrease. However, damage approached pre-installation levels during the final days of the test between 5 and 10 September, when 89 kg/ha per day were lost to blackbirds. This corn field has historically experienced 60–70% damage, or about 175 kg/ha per day annually (J. Besser and J. De Grazio, U.S. Fish and Wildl. Serv., pers. commun.).

Between 400 and 1,600 birds/observation were counted in the field for 6 days (19–25 August) before installing the tape on 26 August. Between 26 and 28 August, almost no birds entered the field. However, between 29 August and 1 September, 3 days after installing the tape, 1,000–1,500 blackbirds (90% yellow-headed and 10% red-winged) began entering a 0.3-ha untaped part of the trial field that was only 10–50 m from the edge of a marsh where up to 75,000 birds roosted. Damage in the taped area of the field nearest the marsh accounted for 18–23% of the total post-installation damage in the taped sections of the field. If reflecting tape had been installed over this 0.3-ha part of the field, birds may not have habituated to the tape quite as rapidly.

Ottawa National Wildlife Refuge.—Red-winged blackbirds were the principal species observed feeding in millet, but a few mourning doves (*Zenaida macroura*), American goldfinches, and house sparrows occasionally entered the field. During the last 2 weeks of the trial, the bird population increased 10-fold with the arrival of brown-headed cowbirds (*Molothrus ater*). Before installing the tape, red-winged blackbirds roosted in trees and bushes near Plot B and fed in that plot (Fig. 5). Birds were not observed roosting near or feeding in Plots C and D at that time. On 21 August, the first day after installing the tape, birds approaching Plot B scattered in all directions. They abandoned their normal loafing sites, moved to a sunflower field, and eventually settled on bushes, trees, and utility wires near untreated Plots C and D. Just before sunset on that day, about 200 birds landed at 1 end of Plot D (farthest from the plot with tape) and fed on millet. These birds were followed by several other flocks that fed in Plots C and D until after sunset, but none fed in the taped area. For 8 days, no birds were observed feeding in the taped plot. In addition, birds entering the untaped plots avoided the taped plot and their former loafing sites. As in the other trials, birds often ascended as they approached the taped plot.

Birds continued to avoid the taped plot un-

Table 3. Bird damage to 0.15-ha plots of ripening millet (1 taped and 2 untaped) before and after installing Bird-Scaring Reflecting Tape® at Ottawa National Wildlife Refuge, Ohio, 1984.

Damage criteria	Taped (Plot B)	Untaped (Plot C)	Untaped (Plot D)
Percent incidence of damage (n = 75)			
Pre-installation	32	21	35
Postinstallation	36	64	84
Additional damage	4	43	39
Percent panicles/damage category (n = 15)			
Pre-installation			
0–25%	73	87	87
26–50%	20	6	6
51–75%	0	0	0
76–100%	7	7	7
Postinstallation			
0–25%	73	0	0
26–50%	27	13	0
51–75%	0	13	33
76–100%	0	87	67
Mean percent decrease in panicle weight, pre- to postinstallation (n = 75)	5	34	52

til 2 September, when a flock of about 100 fed along 1 edge. Tape on this edge was entangled in the millet, and the wind had ceased for several hours, resulting in no movement by other tapes. On 5 September, after tapes had become entangled with millet heads and weeds following a storm, about 3,000 birds moved from the untaped plots and fed in the center of the taped plot. Despite birds eventually breaking into the taped plot, the postinstallation increase in damage was greater in both untaped plots than in the taped plot (Table 3).

Erie County, Ohio.—Bird-Scaring Reflecting Tape® seemed to stop damage to sunflowers by American goldfinches for ≥45–50 days. Although goldfinches were in the area, no bird activity or damage was noted in either the taped or untaped areas of the field until 22 October, 45–50 days after ray flowers began to drop (anthesis). This was in sharp contrast to 1982 and 1983, when commercial oilseed varieties at this location were damaged by goldfinches ≤2 weeks after anthesis and had received >90% damage 40 days after anthesis (R. Dolbeer, pers. commun.). Because taped and untaped portions of the field were undamaged for 45–50 days after anthesis, we cannot, with certainty, attribute the absence of birds to the effect of tape. The population in the area may have been lower than in previous years, or natural food may have been more abundant.

Goldfinches and a few blackbirds began damaging the heads, although minimally, 49–54 days after anthesis. On 26 October, the percentage of heads damaged was 4 times greater in untaped than in taped plots (Table 4). On 2 November, however, percentage damage to heads was 1.3 times higher on untaped than on taped plots. All 3 varieties of sunflower had more damage in the untaped area than in the taped area. Jaques 550, a commercial oilseed variety, was the only variety that incurred >80% damage.

Table 4. Bird damage to 3 varieties of sunflowers in portions of a 0.40-ha field with and without Bird-Scaring Reflecting Tape® in Erie County, Ohio, 1984. Forty heads were examined in each treatment and variety at each date.

		Variety							
		Neagra		BRS-1		Jaques 550		Average	
Date	Treatment	%[a]	%[b]	%[a]	%[b]	%[a]	%[b]	%[a]	%[b]
26 Oct	Taped	0.2	8	0.0	0.0	0.8	13	0.3	7
	Untaped	0.5	18	0.2	13	4.2	58	1.6	29
2 Nov	Taped	0.6	30	0.2	10	7.5	88	2.7	43
	Untaped	1.1	40	0.6	25	27.8	100	9.8	55

[a] Percent seeded surface area damaged.
[b] Percent heads damaged.

These results were particularly encouraging when damage to sunflower plots planted in the same area in previous years was compared (R. Dolbeer, pers. commun.). In 1982, a 0.25-ha plot planted with an oilseed hybrid, Jaques 501, received damage from several hundred goldfinches ≤2 weeks after anthesis, and all seeds were eaten by harvest time. The same damage pattern occurred in 1983 to another 0.25-ha plot planted with 4 sunflower varieties (2 commercial oilseed hybrids, Jaques 501 and 550, and 2 experimental bird-resistant varieties, BRS-1 and Neagra). Within 1 week after anthesis, 100–1,000 goldfinches began feeding on the seeds, and 40 days after anthesis the commercial hybrids averaged >95% loss.

Additional Investigations

Bird-Scaring Reflecting Tape® was tried in several other pest-bird situations. In Haiti, 10-m strips of tape were installed at 5-m intervals over a 0.01-ha plot of ripening sorghum planted at the Ministry of Agriculture Research Station at Damien, Port-au-Prince (J. Keith, U.S. Fish and Wildl. Serv., and R. Cheaney, Texas A&M Univ., pers. commun.). On 16 September, 2 days before installing the tape, village weavers (*Ploceus cucullatus*; $\bar{x}$ = 38/count) and yellow-faced grassquits (*Tiarus divacea*; $\bar{x}$ = 11/count) fed in the plot. Immediately after the tape was installed on 18 September, both species left the plot. Although grassquits continued to avoid the plot, village weavers did not. The following morning, village weavers began returning to the field, but in lower numbers ($\bar{x}$ = 16/count); by 21 September, when pre-installation-size feeding flocks were once again in the field, losses at harvest averaged 25%. No effort was made to modify installation methods to improve the tape's effectiveness.

Bird-Scaring Reflecting Tape® may have other uses. It appeared to protect 4- to 25-m^2 garden plots of tomatoes from speckled mousebirds (*Colius striatus*) in Nairobi, Kenya (M. Jaeger, Food and Agric. Organ., pers. commun.), corn from house crows in Kathmandu, Nepal (G. Alex, U.S. Agency Int. Dev., pers. commun.), and raspberries and strawberries from Brewer's blackbirds (*Euphagus cyanocephalus*) and robins (*Turdus migratorius*), respectively, in Denver, Colorado (R. Bruggers, unpubl. data). In all 3 situations, 2–4 strips of tape were suspended 0.5–1.0 m above the crop. In a nonagricultural use, 15 strips (30 m each) of tape, stretched at 7-m intervals, seemed to stop common crows (*C. brachyrhynchos*) from roosting and pecking holes in a flat 30 × 100-m roof of the DeVry Institute of Technology, Columbus, Ohio (D. Andrews, U.S. Fish and Wildl. Serv., and C. Arnold, DeVry Inst. Tech., pers. commun.). Finally, the tape may have a repellent effect on deer. J. De Grazio (pers. commun.) counted from 3 to 8 white-tailed deer (*Odocoileus virginianus*) entering the corn trial plot at SLNWR on each of 6 mornings (21–26 August) before he installed the tape, but saw no deer entering between 27 August and 1 September, when he discontinued morning observations. Although these are subjective accounts, they suggest situations that may warrant more objective investigations.

CONCLUSIONS

Bird-Scaring Reflecting Tape® provided protection in a variety of bird damage situations in several countries. Despite circumstances unique to each test situation, bird species seemed to respond consistently to tape: 3 species of crows in 4 different countries avoided taped areas; rose-ringed parakeets avoided taped plots of corn and sunflowers; village weavers and munias, at least in the absence of alternative crops, seemed particularly insensitive to the tape when installed at ≥5-m intervals; and red-winged blackbirds seemed to begin habituating to the tape in large corn fields after 3 days, when provided an unprotected entry point to the field.

These preliminary investigations are sufficiently encouraging to warrant large-scale, replicated trials. Such trials should further document responses of pest species to the tape, more accurately detail tape placement and installation methods, evaluate maintenance and cost requirements, and monitor weather effects. Numerous situations exist where, with imaginative installation techniques, this tape might be used to repel or move pest species.

Bird-Scaring Reflecting Tape® presently can be purchased from the 2 previously mentioned distributors in Japan for U.S. $0.36/82-m roll (Maruzen Trading Co., Ltd.) or $0.75/100-m roll (Nishizawa Ltd.), shipping charges not included. The cost of tape (at $0.36/82 m) for use at 10-m intervals in a 1-ha field would be about $4.68. If this tape continues to prove effective, it may provide a simple, inexpensive, and safe technique for agronomists and, more importantly, for traditional farmers in developing countries to protect their crops from bird pests.

SUMMARY

This paper summarizes the results of trials conducted between March 1984 and March 1985 evaluating the effectiveness of Bird-Scaring Reflecting Tape® to protect crops from birds in Bangladesh, the Philippines, India, and the United States. When suspended in parallel rows above ripening crops, reflecting tape reduced damage by rose-ringed parakeet to sunflowers and corn, munias to foxtail millet (in the presence of alternate food), house crows to sunflowers, jungle crows to corn, European tree sparrows to sorghum, and red-winged blackbirds to millet. Village weavers and red-winged blackbirds seemed to habituate rapidly to the tape when applied over a crop in a situation in which they were provided an unprotected entry point to the field. This tape is a synthetic resin film to which a silver layer is applied by vapor deposition, then coated with a colored resin. This tape may offer an inexpensive, simple, safe method for protecting small fields of crops from birds.

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JAGUAR PREDATION ON DOMESTIC LIVESTOCK IN BELIZE

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The jaguar (*Panthera onca*) has been considered a serious predator on domestic animals (Roosevelt 1914, Goldman 1920, Hall and Dalquest 1963, De Almeida 1976, Schaller and Vasconcelos 1978). In the past, ranchers hired men exclusively to hunt jaguar (Guggisberg 1975) and it is still common for bounties to be offered and workers instructed to kill jaguars on sight (Schaller 1980). Yet, jaguar predation on livestock has never been closely examined. Some reports (Leopold 1959, Hall and Dalquest 1963) indicate only certain individuals kill domestic stock and when these jaguars are killed, losses cease, even with other jaguars in the vicinity. Roosevelt (1914) stated that confirmed cattle killers were mostly old males, while Schaller and Crawshaw (1980) showed that, in the Pantanal of Brazil, seemingly healthy adult jaguars feed on livestock as normal prey items.

The purpose of this study was to investigate jaguar-livestock interactions and to assist the government of Belize in developing management guidelines for the control of livestock herds.

STUDY AREA

The study was conducted from March 1983 through January 1985 within the Cockscomb Basin of southern Belize. The study area was 425 km^2 of subtropical wet forest, ranging in elevation from 0 to 600 m. Major land uses in the vicinity included cattle and swine ranching, citrus crops, and small patches of Mayan Indian settlements practicing slash-and-burn agriculture. The field station, Guam Bank, was 10 km into the basin on the site of an abandoned logging camp and contained a small Mayan settlement of 9 families with numerous dogs and domestic swine.

METHODS

Five prime adult male jaguars were captured 10 times during the study with dogs used to tree the cats or with traps baited with pigs. One subadult female and 1 subadult male jaguar captured over cattle kills in northern Belize were moved into Cockscomb to investigate the results of translocation. Captured animals were immobilized with ketamine hydrochloride (Parke, Davis & Co., Detroit, Mich.) administered at 22 mg/kg of body weight and fitted with radiocollars containing activity monitors (Telonics, Mesa, Ariz.). Attempts were made at least 3 times weekly to locate collared jaguars using either directional antennas on the ground, from tall trees, or in aircraft. Location data were used to ascertain home ranges with the minimum-area method (Mohr 1947). "Problem jaguars" denotes animals killed or captured in pastures or villages over dead livestock. "Nonproblem" jaguars were those captured or killed in their natural habitat and not known to prey upon domestic stock. Age categories were determined from tooth eruption and attrition (De Almeida 1976) and from cranial suture closure, assuming the same general anatomical progression for jaguars as for the African lion (*P. leo*) (Smuts et al. 1978). Jaguars were classified either as subadults (2–3 years), prime adults (4–10 years), or old adults (>11 years).

RESULTS

Nonproblem Jaguars

On 28 July 1983, a prime adult male jaguar, #545, was captured 3 km west of Guam Bank.