Scaring Effectiveness of Eyespot Balloons on the Rufous Turtle Dove, *Streptopelia orientalis* (LATHAM), in a Flight Cage

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The effectiveness of two types of eyespot balloons at causing avoidance by birds was examined in a flight cage using three captive doves, *Streptopelia orientalis*. A field where soybean seeds were systematically placed was divided into several plots in which the following three treatments were applied: placing of balloons with and without eyespots and no placing of balloons. The effectiveness of balloons was compared in terms of preference for the plots, calculated by measuring the number of beans eaten. Doves showed a tendency to avoid plots that had balloons. However, the intensity of avoidance differed between balloons with and without eyespots only in the first experiment, although the differences were not significant. That is, the scaring effectiveness of eyespot patterns is not very strong, and becomes extinct rapidly. These results suggest that the scaring effectiveness of eyespot balloons is mainly due to the curious stimulus of balloons rather than to the eyespot patterns themselves.

Key words: *Streptopelia orientalis*, eyespot balloons, scaring, pest birds

INTRODUCTION

Eyespot patterns have long been used by Japanese farmers to prevent bird damage to crops (SUGAHARA and SINDO, 1988). Farmers would hang a board on which a kind of eyespot pattern was drawn on a pole or rope in crop fields. Recently, many kinds of balloons with eyespots have become widely used in Japan for scaring pest birds from crop fields or orchards. These eyespot patterns are thought to be a mimicry of vertebrate eyes. In the laboratory, such patterns have induced an intrinsic fear and aversive response in birds (BLEST, 1957; SCARIFE, 1976; SHIROTA, 1980; INGLIS et al., 1983).

However, the actual effectiveness of eyespot pattern devices on scaring birds in fields has been examined by only a few authors. SHIROTA et al. (1983) reported the reduction of damage by gray starlings, *Sturnus cineraceus*, to grapes and peaches by use of a balloon (2.6 m in diameter) with eyespots. SHIROTA (1989) succeeded in scaring two species of crows, *Corvus macrorhynchos* and *C. corone* from their roost by a combination of eyespot and “predatory bird” balloons. However, in these experiments the effect of only the eyespot balloons was examined, without a comparison to “control” balloons having no eyespots. Therefore, it is not apparent whether the effectiveness shown was due to the eyespot pattern or to the balloon itself.

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Fig. 1. The field and the arrangement of plots for experiments.

AVERY et al. (1988) examined the effectiveness of eyespot balloons in discouraging boat-tailed grackles, *Quiscalus major*. They recorded the mean distance of birds from trees when a balloon with or without eyespots was placed near the trees. The distance was longer for a white balloon with eyespots than for balloons without eyespots, but no effect due to eyespot balloons was recognized in birds observed within 1 m of the trees. Thus, this experiment also failed to show a clear effectiveness of eyespot balloons compared with balloons without eyespots.

In this paper, we examine the effectiveness of the two different type of balloons at scaring the rufous turtle dove, *Streptopelia orientalis*, in a flight cage. Effectiveness is compared between balloons with and without eyespots to determine whether the fear response is due to the eyespot pattern or to the balloon itself.

METHODS

Experiments were conducted in a flight cage that measured 20 m wide $\times$ 60 m deep $\times$ 12 m high. Small polypropylene cups that were 4.5 cm in diameter and 3.5 cm in height were placed on the ground in the cage as containers for food. The cups were arranged in a field, 11 m $\times$ 48 m, in a grid of 12 rows 1 m apart from each other, and 120 columns, 40 cm apart from each other, for a total of 1,440 cups. This experimental field was divided into 16 plots, each 5.5 m $\times$ 6 m, and containing 90 cups. Plots were labeled A1 to H2 (see Fig. 1). Three doves, which had been reared on grain in the laboratory after being captured in the field, were introduced into the cage.

All experiments conducted were started on Monday and finished on Saturday of the same week. Every Monday morning, one soybean seed was placed in each cup and balloons were set up except in the blank experiment. All cups were examined every morning thereafter at 0900 h and the location of all cups in which soybeans had been eaten by doves was recorded. If a soybean was removed from a cup but not eaten, it was placed back in the cup after its location was recorded. On Saturday morning, all uneaten soybeans and balloons were removed. The amount of food (a mixture of several cereal seeds) eaten per day was fed to the doves on Saturday and Sunday.

The following four experiments were conducted with no repetition in the sequence described below, using the same individual doves from October to November, 1984.

Experiment 1: Blank experiment. In order to determine the bird preference for each plot

Fig. 2. Balloons used for experiments. (A) Two-eyed balloons. (B) Crow-shaped balloons.

in the experimental field, an experiment was conducted with no balloons.

Experiment 2: Red two-eyed balloons. Two-eyed balloons used in this experiment (Fig. 2A) had been designed by SHIROTA based on laboratory experimental results using *S. cineraceus*. This balloon had two “eyes” 47 cm in diameter with a distance of 23 cm between the edges of both eyes. The base color of the balloons was red and the eyespot balloons had a black eyelid (outer diameter 30 cm) with a red iris (outer diameter 21 cm) and a black pupil (outer diameter 15 cm).

One of the following three treatments was systematically assigned to each plot: no balloons in 8 plots (A2, B1, C2, D1, E2, F1, G2 and H1), balloons with eyespots in 4 plots (A1, D2, E1 and H2) and control balloons without eyespots in 4 plots (B2, C1, F2 and G1). One balloon was hung on a pole with a string at ca. 1 m above the ground at the center of a plot. The balloons moved easily with the breeze.

Experiment 3: Black balloons shaped like a crow. Balloons used in Experiment 3 (Fig. 2B) had also been designed by SHIROTA and induced a strong aversive behavior in *S. cineraceus* (SHIROTA, unpublished data). These had a shape like a crow 45 cm in diameter and 75 cm in height with two bills 11 cm in length. The base color of these was black (including bills) and they had two eyespots with a yellow iris (outer diameter 12 cm) and a black pupil (outer diameter 7.5 cm).

One of three treatments was assigned to each plot: no balloons in 8 plots (A1, B2, C1, D2, E1, F2, G1 and H2), balloons with eyespots in 4 plots (A2, D1, E2 and H1) and those

without eyespots in 4 plots (B1, C2, F1 and G2). Balloons were set up in the same manner as in Experiment 2.

Experiment 4: Red and yellow two-eyed balloons. The experimental field was divided into east and west sides, having 8 plots each. In the western part (A–D), red two-eyed balloons that had been used in Experiment 2 were arranged systematically: the balloons with eyespots in 4 plots (A2, B1, C2 and D1) and those without eyespots in 4 plots (A1, B2, C1 and D2). In the eastern part (E–H), the same balloons with a yellow base color were arranged in the same way as the red balloons; that is, balloons with eyespots in 4 plots (E2, F1, G2 and H1) and those without eyespots in 4 plots (E1, F2, G1 and H2). Therefore, balloons were set up in all plots leaving no blank plots in this experiment.

Comparison of scaring effect of balloons. To compare the bird preference between two plots with different treatments (for example, balloon and blank plots), a measure of preference, α_i , in the i th plot was calculated according to MANLY et al. (1972):

$$\alpha_i = \frac{\ln((n_{i0} - r_i)/n_{i0})}{\sum_{j=1}^2 \ln((n_{j0} - r_j)/n_{j0})} \quad (i = 1, 2)$$

where n_{i0} is the number of beans of the i th plot present at the beginning of an experiment and r_i is the number of beans eaten until a certain time after the beginning in the same plot. ($n_{10} = n_{20} = 90$ in the present experiments.)

When $\alpha_1 = \alpha_2 = 0.5$, birds visit the two plots equally. When $\alpha_1 < 0.5$, birds avoid the first plot more than the second one. We obtained values of α_i for each pair of plots for two different treatments in the morning on each day after the beginning of an experiment, assuming that birds continued to eat food without interruption of eating at night. Thus, we obtained a sequence of values of α_i during an experiment.

Regarding that the values of α_i are a sample from a multivariate normal distribution (CHESSON, 1983), the null hypothesis of no preference (i.e., $\alpha_1 = \alpha_2 = 0.5$) was tested using the t statistic,

$$t = \frac{\bar{\alpha}_i - 0.5}{\sqrt{s^2/n}} \quad (i = 1, 2)$$

where $\bar{\alpha}_i$ is the sample mean and s^2 is the sample variance of the n estimates of α_i .

In Experiments 2–4, doves did not eat any beans from some plots on the first day (Monday), probably because they were not hungry after the free feeding of cereal seeds on Saturday and Sunday. The preference index was calculated as 0.0 or 1.0 when no consumption occurred in one of two plots. Sometimes, it was not possible to calculate preference index because no consumption occurred in either of the plots for which the preference was compared. As a result, the value of α_i on the first day often varied greatly. Therefore, mean preference indices on the first day, $\bar{\alpha}_i$, were not used in Experiments 2–4.

RESULTS

1. The number of beans eaten daily

Figure 3 shows the cumulative number of beans eaten by three birds until the morning of each day in Experiment 1, where no balloons were set up in the field. The cumulative number of beans eaten increased proportionally with the passage of days, showing that an

Fig. 3. Cumulative number of beans eaten each day after the start of the experiment where no balloons were placed in plots (Experiment 1).

Table 1. Consumption rate of beans for day in each experiment

Exp. No.	1	2	3	4
Consump. rate	248.9	281.2	287.6	263.8

almost constant number of beans was eaten every day. In other words, the consumption rate per day did not change with the passage of days and enough beans remained to provide food even for the last (fifth) day. The consumption rate per day was determined to be 248.9 from the value for the coefficient in the regression equation obtained from the result in Fig. 3.

Similar results were also obtained for the other experiments, and the numbers of beans eaten per day (consumption rates) were determined (Table 1). Since initially 1,440 beans were placed in the field, the mean maximum number of beans which doves could take per day was 288. Therefore, doves took beans at nearly the maximum rate in Experiments 2 and 3, while the consumption rates in the other two experiments were lower than the maximum. The lowest rate in Experiment 1 suggested that doves were more or less unfamiliar with the beans and/or new food sites at this time.

2. Bird preference for different site in the experimental field

Doves usually perched on beams along the wall of the western side of the cage at night, and began to eat beans at the edges of the field in the morning. As a result, the ratio of beans eaten in a plot showed a strong heterogeneous distribution. Because of this heterogeneous distribution in consumption rate, we cannot compare the preference between plots pooled for each treatment, but must compare it between two plots where the consumption rates do not differ significantly.

The value of α_i was obtained for each pair of adjoining plots and the difference from 0.5 (i.e., hypothesis of equal preference) was tested using t -values. First, preference for a pair of plots was compared between the southern and northern side plots (for example, A1 and A2, B1 and B2, etc.). As doves apparently preferred different sides between the eastern five pairs of plots (A-E) and the western three pairs (F-H), comparisons were made separately in these two parts (Table 2). In the eastern part, southern side plots were always significantly

Table 2. Comparison of bird preference in two adjoining plots on each day when no balloons were placed in the field (Experiment 1)

Day	1st	2nd	3rd	4th	5th
Between plots arranged in a south-north direction					
i) Eastern part of the field (A-E) ($n = 5$)					
$\bar{\alpha}_1$	.7610	.6714	.6807	.7068	.6338
P	< .01	< .02	< .02	< .001	< .01
	**	*	*	**	**
ii) Western part of the field (F-H) ($n = 3$)					
$\bar{\alpha}_1$	.4026	.3025	.3129	.4194	.3930
P	> .50	> .10	< .05	> .20	> .10
	n.s.	n.s.	*	n.s.	n.s.
Between plots arranged in an east-west direction ($n = 6$)					
$\bar{\alpha}_1$	.4828	.6335	.5705	.5635	.5865
P	> .50	> .10	> .10	> .05	> .10
	n.s.	n.s.	n.s.	n.s.	n.s.

$\bar{\alpha}_1$ is the mean value of MANLY's measures in the 1st of two plots (i.e., the southern plots in the first two comparisons and the eastern plots in the third comparison), and P is the probability at which the null hypothesis of no preference between two plots is rejected. *, **: the hypothesis is rejected at a probability of less than 0.05 and 0.01, respectively. n.s.: not significant.

preferred to the northern side ones during the five days. The tendency of preference was reversed in the western side, although a significant difference was obtained only on the 3rd day.

Next, preference was compared between the two adjoining plots east- and westward (for example, A1 and B1, A2 and B2, etc.). In this comparison, the most eastern (A1 and A2) and most western plots (H1 and H2) were omitted because an apparently higher consumption rate was observed in these edge plots than in other plots in the inner part of the field. Thus, we compared the preferences between B1 and C1, between D1 and E1 or between F1 and G1, etc. The results show that there was no significant difference between these two plots in all five days during the experiment (Table 2), indicating that the comparison of different treatments should be made between these two plots.

3. Effectiveness of balloons

1) *Red two-eyed balloons (Experiment 2)*. According to the results in the preceding section, α_i was compared between two adjoining plots situated east-to-westward, omitting the most eastern and most western plots. For these comparisons, however, there remained only three (B2 vs. C2, C1 vs. D1 and F2 vs. G2) and two pairs of plots (D2 vs. E2 and E1 vs. F1) between the control balloon plots and blank ones, and between the eyespot balloon plots and blank ones, respectively. We also tested the hypothesis of equal preference between balloon (with and without eyespots) and blank plots ($n = 5$). Doves showed a significant preference for blank plots over balloon plots in three of four days. They showed a stronger avoidance toward eyespot balloon plots than toward control balloon ones (Table 3).

2) *Black balloons shaped like a crow (Experiment 3)*. As in Experiment 2, we compared the values of $\bar{\alpha}_i$ between two adjoining plots situated east-to-westward. There were three pairs of plots (B1 vs. C1, C2 vs. D2 and F1 vs. G1) and two pairs of plots (D1 vs. E1 and E2 vs.

Table 3. Comparison of bird preference in two adjoining plots with different treatments on each day when red two-eyed balloons were placed in the field (Experiment 2)

Day	2nd	3rd	4th	5th
Between plots with control balloon and no balloon ($n = 3$)				
$\bar{\alpha}_1$	.2409	.3942	.3160	.4214
P	> .10	> .50	> .20	> .20
	n.s.	n.s.	n.s.	n.s.
Between plots with eyespot balloon and no balloon ($n = 2$)				
$\bar{\alpha}_1$	.0818	.1707	.2416	.3197
P	> .10	> .50	> .50	> .50
	n.s.	n.s.	n.s.	n.s.
Between plots with balloon and no balloon ($n = 5$)				
$\bar{\alpha}_1$	.1772	.3048	.2863	.3807
P	< .01	> .10	< .05	< .05
	**	n.s.	*	*

$\bar{\alpha}_1$ is the mean value of MANLY's measures in the 1st of two plots (i.e., the plots with control balloon, eyespot balloon and balloon of both types for the first, second and third comparisons, respectively). Others are the same as in Table 2.

Table 4. Comparison of bird preference in two adjoining plots with different treatments on each day when the balloons shaped like crows were placed in the field (Experiment 3)

Day	2nd	3rd	4th	5th
Between plots with control balloon and no balloon ($n = 3$)				
$\bar{\alpha}_1$	.3539	.2120	.2540	.4697
P	< .05	< .05	> .05	> .40
	*	*	n.s.	n.s.
Between plots with eyespot balloon and no balloon ($n = 2$)				
$\bar{\alpha}_1$	.1264	.2209	.2209	.4652
P	> .10	> .10	< .01	≠ .50
	n.s.	n.s.	**	n.s.
Between plots with balloon and no balloon ($n = 5$)				
$\bar{\alpha}_1$	.2629	.2155	.2214	.4679
P	< .02	< .01	< .001	> .10
	*	**	**	n.s.

For $\bar{\alpha}_1$, see Table 3.

F2) for the comparisons between control or eyespot balloons and no balloons, respectively. We could not detect any difference in $\bar{\alpha}_i$ between both comparisons (Table 4). Comparison between plots with and without balloons shows that doves had a tendency to avoid balloon plots except on the fifth day (Table 4).

3) *Red and yellow two-eyed balloons (Experiment 4).* In this experiment, only two samples each are available to compare the preference between control and eyespot red (B1 vs. C1 and C2 vs. D2) and yellow (E2 vs. F2 and F1 vs. G1) balloons. We also tested the hypothesis of equal preference between balloon plots with and without eyespots, disregarding the colors of balloons. In this comparison another pair of plots (D1 vs. E1) was also available, so

Table 5. Comparison of bird preference in two adjoining plots with different treatments on each day when red and yellow two-eyed balloons were placed in the field (Experiment 4)

Day	2nd	3rd	4th	5th
Between plots with red eyespot and control balloons ($n = 2$)				
$\bar{a}_1$	.6631	.6206	.5174	.5209
P	> .10	> .40	> .90	$\approx$.50
	n.s.	n.s.	n.s.	n.s.
Between plots with yellow eyespot and control balloons ($n = 2$)				
$\bar{a}_1$	.3607	.4294	.3622	.4103
P	> .20	> .50	< .02	> .50
	n.s.	n.s.	*	n.s.
Between plots with eyespot and control balloons ($n = 5$)				
$\bar{a}_1$	.4299	.4558	.4300	.4725
P	> .50	> .50	> .20	> .50
	n.s.	n.s.	n.s.	n.s.

For $\bar{a}_1$, see Table 3.

that we had five pairs of plots.

No tendency to avoid the eyespot balloon plots was shown for the balloons of each color, except in one case (Table 5). No significant differences were detected in preference between balloon plots with and without eyespots when a comparison was made disregarding the colors of the balloons (Table 5).

DISCUSSION

In comparisons of preference between balloons with and without eyespots, an avoidance tendency was observed only for the red two-eyed balloons (Experiment 2; Table 3), but no difference was detected between the same balloons when all plots had balloons placed in them (Table 5). Since eyespot balloons were first presented to doves in Experiment 2, there is a possibility that doves avoided the eyespot balloons the first time, but became habituated to this stimulus by the second time.

INGLIS et al. (1983) presented many kinds of eyespot patterns to starlings in the laboratory and found that some kinds of eye patterns caused aversive reactions in birds. However, they also revealed an order effect that resulted from a decline in fear as the trials progressed, suggesting a limit of the usefulness of these patterns in scaring birds. HORIKAWA et al. (1988) examined the response of *S. orientalis* to several kinds of eyespot pattern drawn on a white board in a flight cage, but they did not confirm any difference in the bird's behaviors. We can conclude from these results that even if balloons with eyespots are effective at scaring doves, the habituation rate is certainly too high to allow practical use of such techniques.

In Experiments 2 and 3, where no balloon (blank) plots were arranged with balloon plots, doves significantly preferred to feed in blank plots rather than in balloon ones. These results show that balloons themselves have a scaring effect for doves under conditions where alternative food is available to them, irrespective of whether eyespots are present or absent on the balloons. This avoidance by doves of plots with balloons was apparently caused by a response to the curious stimulus of balloons. As animals habituate rapidly to these stimuli (INGLIS, 1980), the effectiveness of balloons will limit their practical use in fields. In fact, a

slight reduction was observed in soybean damage due to *S. orientalis* when several kinds of eyespot balloons were placed in the open field (YUI, 1988), but no reduction was observed for feral pigeons, *Columba livia* (SHIMIZU et al., 1988).

The addition of eyes to model owls enhanced the intensity of mobbing that these models evoked (CURIO, 1975), although a similar effect was not clear in starlings (INGLIS et al., 1983). Doves and pigeons show a strong response to a human effigy (YUI, 1988; SHIMIZU et al., 1988), although the intensity of the response varies depending on the existence of alternative foods (WATANABE et al., 1988) and from individual to individual (MATSUOKA, 1989). These facts suggest that *S. orientalis* shows stronger avoidance for models that more accurately mimic the predator's image (INGLIS, 1980) than for simple eyespot patterns.

Since these experiments were conducted in a closed cage, dove preference varied largely from plot to plot even under no balloon conditions (Table 2). This made it difficult to analyze the results obtained, because the number of plots available for comparison of the effects of different treatments was limited. A heterogeneous distribution of dove preference in space is also observed in open fields (KENWARD, 1978; NAKAMURA and MATSUOKA, 1987), causing the same difficulty of analysis for data obtained there. Thus, the experimental design adopted here, or a comparison of plots with different treatments appears to be inappropriate for investigating the effectiveness of bird scarers. More appropriate methods should be developed for such tests.

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