An attempt to investigate color preference using eight cases of captive Japanese wild birds

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Abstract

Bird repellent devices have been used extensively to induce wild bird pests to avoid otherwise attractive or palatable materials. Although color has long been considered a potential visual repellent among birds, which colors are commonly unattractive to wild bird species in Japan has not yet been elucidated. We have obtained eight cases of captive Japanese wild birds to investigate their color preference, resulting in a consistent color preference among them. The birds used in the present attempt consisted of an individual each of eight species: tree sparrow (Passer montanus), rufous turtle dove (Streptopelia orientalis), bamboo partridge (Bambusicola thoracica), brown-eared bulbul (Hypsipetes amaurotis), crested myna (Acridotheres cristatellus), dusky thrush (Turdus naumanni), azure-winged magpie (Cyanopica cyanus), and black kite (Milvus migrans). The birds were presented with four feeders that had lids colored red, yellow, green, and blue. None of the birds selected yellow or blue as their very first choice. In addition, preference scores differed between the four colors. All birds showed the less preference for yellow, and also blue was less preferred by most of the birds. In contrast, most birds preferred red and green. Thus, there was a significant difference between the scores of yellow and green. The findings of the present evaluation suggest that yellow is better suited for controlling birds and also blue would be a good color, but that red and green are not so suitable for visual repellents. To increase the efficacy of colors for deterring birds, further investigation would be desirable to combine the initial deterrence of the visual repellents with other aversive stimuli, such as chemosensory repellents or frightening agents.

Key words: wild birds, visual repellent, color preference, case study, yellow

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Introduction

The activities of wild birds often conflict with those of humans. Birds have caused extensive damage to agricultural produce in rural areas, and become a public nuisance in urban areas (De Grazio 1978; Fitzwater 1988; Messner 2000; Bruggers et al. 2002; Fall & Jackson 2002). For example, just under 30% of damage to agricultural production in Japan by wildlife is caused by birds (Ministry of Agriculture, Forestry and Fisheries 2010; Ministry of Agriculture, Forestry and Fisheries 2011). In addition, their tendencies to defecate in public areas, scatter garbage and sometimes get close to humans without any fear not only make them a public nuisance, but also can adversely effect human health and safety in urban areas (De Grazio 1978; Bruggers et al. 2002; Karasawa 2011).

Repellent substances and devices cause pest species to avoid otherwise attractive or palatable materials. Birds are extremely visual animals, and as our former study has already demonstrated, they have a well developed capacity for visual learning (Gill 2006; Ueno & Suzuki 2014). Consequently, visual cues, such as aposematic coloration, can act as potential repellents and they can facilitate learning to avoid secondary repellents. For instance, in a study on house sparrows, blue-coated bait items were consumed significantly less frequently than uncoated bait items (Pawlina & Proulx 1996; Clapperton et al. 2011). In addition, chemical repellents inducing taste aversion or gastrointestinal malaise were more effective when combined with colored bait or flags (Mason & Reindinger 1983; Avery & Mason 1997; Werner et al. 2008; Clapperton et al. 2011). Color cues therefore seem to be very important primary repellents for scaring bird pests. Nonetheless, the colors with the
greatest potential for repelling both known and potential pest bird species have yet to be clarified in Japan.

We have obtained eight cases of captive Japanese wild birds, i.e. tree sparrow (Passer montanus), rufous turtle dove (Streptopelia orientalis), bamboo partridge (Bambusicola thoracica), brown-eared bulbul (Hypsipetes amaurotis), crested myna (Acridotheres cristatellus), dusky thrush (Turdus naumannii), azure-winged magpie (Cyanopica cyanus), and black kite (Milvus migrans), in order to investigate their color preference, resulting in a consistent color preference among them. The present case study is the first reported attempt to evaluate the Japanese wild birds' color preference.

All of the species tested in the present investigation are typically associated with human habitation, implying that they could easily affect human activities, particularly the sparrows, doves, bulbul and azure-winged magpies, which can all damage agricultural crops (Eguchi et al. 2002). Crested mynas, which often construct their nests on buildings, are an exotic species that is spreading rapidly in Japan (Eguchi & Amano 2004).

Materials and Methods

Animals and housing

The present experiment examined color preference in an individual of each of the following eight bird species: tree sparrow, rufous turtle dove, bamboo partridge, brown-eared bulbul, crested myna, dusky thrush, azure-winged magpie, and black kite. The birds tested consisted of rescued birds that were transferred from the Yokohama Zoological Gardens of Yokohama, Kanazawa Zoological Gardens of Yokohama, Nogeyama Zoological Gardens of Yokohama and Yumenigasaki Zoological Park of Kawasaki, to the Tokyo University of Agriculture and Technology Field Science Center for scientific research. Although all of the birds had previously been physically injured, their condition was stable and their injuries did not interfere with daily activities such as feeding or moving about in cages. Birds were housed individually in experimental cages made of wood (dimensions: W60×H90×D90 cm for the azure-winged magpie, 105×125×95 cm for the black kite, and 30×45×90 cm for the other birds). Food was provided ad libitum after the daily tests which started at 8.00, but removed at 17.00. Water was provided ad libitum. The birds were maintained in a constant environment room at a temperature of 24°C and under a photoperiod of 10L/14D. During the experiments, experimental cages were evenly illuminated by neutral white florescent lights.

The present study was conducted on the required registration for keeping wildlife and permission from the Tokyo University of Agriculture and Technology Laboratory Animal Care and Use Committee.

Experimental procedure

The experiment consisted of 5-day acclimatization period followed by a 5-day color preference test. In the acclimatization period, birds were habituated to the experimental apparatus and the procedures employed for the color preference test. After this acclimatization period, the reactions to color cues were tested using four colors in a color preference test.

Experimental stimuli

The color preference test consisted of presenting the birds with cues in the form of colored feeder lids (diameters: 4.2 cm for the tree sparrow, 7.7 cm for the black kite, and 6.2 cm for the other birds), which meant birds had to insert their beaks from the open part of colored lid to get food in the feeder. Feeders were supported by feeder holders, which were arranged in a grid consisting of two rows and two columns in the experimental cage (Fig. 1).

As the lid colors standardized following the Cyan Magenta Yellow Key plate color model, red (0.77.68.13.C.M.Y.K), yellow (0.13.100.4), green (100.0.44.40) and blue (100.35.0.33), were presented. Experimental food in each feeder was a mealworm for the tree sparrow, pigeon feed for the rufous turtle dove, fowl feed for the bamboo partridge, a pellet of commercial myna food for the brown-eared bulbul and crested myna, a pellet of commercial dog food for the dusky thrush and azure-winged magpie, and a slice of chicken liver for the black kite.

Acclimatization Period

Over three successive days of the acclimatization period, birds acquired the skills necessary for performing the test, i.e. inserting the beak into the feeder from the open part of the lid to obtain food; feeders with white lids were used for this stage of the experiment. On the first day of training, birds were trained to eat from the feeders with open lids. On the second and the third days, the lids were partially closed, which meant that the birds could see the food but they had to insert their beaks into the feeder from the open part of lid to obtain food. Four feeders were presented on a 2×2 grid for every trial, and training sessions lasted 30 minutes each day. Feeders were replaced and the next trial was started when birds emptied all four feeders or when no more selections were made for 15 minutes. These procedures made it certain that birds had no preference for the position of feeders.

Color Preference Test

In the color preference test, four colors, red, yellow, green and blue were presented on the lids of four feeders (Fig. 1). The lids were partially closed, as they were on the second and third days of training in the acclimatization period, which meant that birds could see the food but they had to insert their beaks into the feeder from the open part of the lid. Once the birds had emptied all four of the feeders, or if no further
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![Diagram](image)

**Data analysis**

The number of trials made by birds in the whole preference test were as follows: 6 trials by the tree sparrow, 5 by the rufous turtle dove, 11 by the bamboo partridge and brown-eared bulbul, 31 by the crest ed myna, 10 by the dusky thrush and azure-winged magpie, and 4 by the black kite. To assess the presence of consistent color preference among the tested birds, the very first choice in the first trial and the mean scores assigned to each color of all trials in each bird were used. In addition, mean preference scores of each color, calculated from the scores in each bird, were compared. To detect a significant difference, a Friedman test \( (P < 0.05) \) was used. Then, Wilcoxon signed rank tests \( (P < 0.05) \) followed by Bonferroni corrections were undergone for multiple comparisons.

These statistical analyses were conducted using the statistical package R.

**Results**

All of the birds in the color preference test selected either red or green as their very first choice (Fig.2); none of the birds selected yellow or blue the very first time. Thus, all of the birds gave high scores to yellow, and most of the birds also gave a high score to blue. (Fig.2).

Friedman test revealed that the preference scores assigned by birds differed significantly among four colors \( (x^2 = 11.0, P = 0.01) \). Wilcoxon signed rank tests followed by Bonferroni corrections revealed that the scores assigned to yellow were significantly higher than the scores assigned to green. Blue and red were assigned the intermediate scores between yellow and green, but blue was given relatively high scores compared to red (Fig.3). These would have been caused by the result that most birds more or less preferred red and green to yellow and blue, with some exceptional preferences that the tree sparrow and dusky thrush showed a strong preference for green and blue compared to red and yellow (Fig. 2).

As a result in the present study, yellow was the only color that was assigned high scores by all of the bird species tested: yellow was always given scores of over 3, i.e. the middle of 1-5 points (Fig. 2), whereas blue revealed a relatively high score (Fig. 3).
Discussion

Wild birds can cause serious damage to agricultural production and can disrupt human activities. Although color has been considered for use as a visual repellent for chasing bird pests, no scientific information on common color preference among Japanese wild birds has been published to date. This experiment therefore attempted to evaluate color preference among wild birds in Japan.

The results showed that no birds selected yellow or blue as their very first choice. In addition, all of the birds gave a high score to yellow, and most of the birds also gave a high score to blue. These suggest that yellow and blue are less preferred colors. These findings partly corroborate previous studies in other bird species, which showed that blue was the least attractive color for birds (Gionfriddo & Best 1996; Hartley et al. 1999; Hartley et al. 2000). However, yellow was an attractive color in most studies (Gionfriddo & Best 1996; Hartley et al. 1999; Hartley et al. 2000). Two factors may explain the apparent
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inconsistency regarding the observed reactions to color stimuli reported in the literature. First, since there is currently no specific information on color preference in various wild birds in Japan, the present results may be the first evidence to show that wild birds in Japan have characteristic color preferences. Second, the previous studies presented color stimuli in the form of colored bait. However, food preference may not be influenced by color alone, but also by whether the colored food appears palatable (Gamberale-Stille & Tullberg 2001). Thus, in the previous studies employing colored bait, birds may have preferred yellow simply because the food appeared more palatable. Since this study presented color cues on the feeder covers, the color preferences observed among birds in this study cannot be considered to have been influenced by the appearance of palatability. In this way, the observed results are considered to be similar to the reactions of birds toward colored covers or flags that protect bird attractors.

The findings of the present study demonstrated that, since yellow was less preferred by Japanese wild birds, yellow would be better suited for use as a visual repellent, particularly in the form of colored covers or flags. By extension, blue would also be good, but red and green would be less suitable for use as visual repellents.

However, color alone cannot elicit sustained avoidance responses, even if a particular color is strongly avoided initially (Hartley et al. 2000; Clapperton et al. 2011). Over time, birds would learn that the aversive color may in fact be associated with an attractive resource instead of with danger. Thus, to make color repellents more effective and sustained, it would be more effective to use a visual repellent as the key stimulus responsible for inducing the avoidance response, and then to augment that initial deterrence with aversive stimuli such as chemosensory repellents (e.g. repellents associated with taste aversion or gastrointestinal malaise) or frightening agents (e.g. warming shots or driving) to induce avoidance learning.

When also using a cover or flag to induce avoidance learning, yellow might be the effective color. Ham et al. (2006) reported that experimental prey with yellow cover was avoided significantly more than prey with a red cover after taste aversion conditioning to prey of both colors. In order to maximize the potential effectiveness of color as a practical repellent, the methods of the present study should be incorporated into an investigation examining which colors are more memorable when used as visual cues for avoidance learning, and whether color cues can be used to exclude bird pests even when the attraction is not food, e.g. public spaces or articles.

References


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日本産野鳥8例の飼育実験による色選好性試験

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要約

野生鳥類による食物や人工物への被害を防ぐ方法として、防鳥資材の活用がある。色は防鳥効果を持ち視覚的なシグナルとして知られるが、実際にどの色が回避されやすいのかを多種について調査した例は日本にない。本飼育実験では、日本国内に生息するスズメ(Passer montanus)、キジバト (Streptopelia orientalis)、コジュケイ (Bambusicola thoracica)、ツグミ (Turdus naumanni)、ヒヨドリ (Hypsipetes amaurotis)、ハッカチョウ (Acridotheres cristatellus)、オナガ (Cyanopica cyanus)、トビ (Milvus migrans) の計8種について各色の選好性を調査したところ、一貫性のある所見を得た。色の選択性は赤、黄、緑、青の4色とし、これらの色の蓋によって覆われた4つの餌入れを同時に提示し選択性させることで実験を行った。実験開始時の最初の選択性において、黄および青を選択した個体はなかった。また、黄は全個体において回避される傾向にあり、青も多くの個体において回避された。一方で、多くの個体が赤と緑に対し選好傾向を示した。この結果、黄・緑間では選好性に有意差が見られた。本結果は、黄は防鳥効果が高く青も比較的鳥害予防に活用しやすいと考えられるが、赤と緑は防鳥効果があまり高くない可能性を示唆している。防鳥効果の高い色をより効果的に且つ長期に亘って活用するためには、これを単独で用いるだけでなく、化学防鳥剤や脅喝による追い払いといった他の防鳥刺激と組み合わせる研究が有効であると考えられる。

キーワード：野生鳥類, 視覚的防鳥刺激, 色の選好性, 事例研究, 黄色

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