THE SELECTION OF COLORED NEST BOXES BY HOUSE WRENS

By Robert A. McCabe

This paper describes and evaluates a field experiment on the choice of colored nest boxes by House Wrens (*Troglodytes aedon*). The literature on the experimentation with color recognition and color discrimination among animals, and among birds in particular, is relatively large and spans a considerable time period. A brief summary is given by Smith (1945). A general review of past experimentation for comparison with my study left one outstanding impression, namely, that a review of color vision in birds is urgently needed. Such a review is not attempted here. The first part of this paper, however, will endeavor to sample the available works in order to point up the complexity of color appraisal. In only a few relevant cases was an effort made to cover the substantial, untranslated foreign literature.

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SOME COLOR RELATIONSHIPS AMONG BIRDS

Color differentiation by birds is said by Worden (1958?) to have been postulated by Thomas Young in 1807. Testing of color awareness was at first confined largely to laboratory research (Yerkes, 1915; Lashley, 1916; C. Hess, 1907; Bailey and Riley, 1931; Walls, 1942; and others). In general, it can be said that physiologically birds distinguish color, although the spectrum range is not clearly defined; that diurnal birds are stimulated more by red-yellow color bands and nocturnal birds by blue-green color bands; that birds generally react to color on the basis of wave length, that is, color tone; that the function of the oil droplets of the retina as color filters is not completely understood; and lastly, that there is some evidence to show that when the intensity of illumination is decreased, the darkening effect is greater on red, orange and yellow than on blue or green, so that the point of maximum brilliance in the spectrum under reduced illumination shifts from yellow into green (Purkinje effect).

Investigations into the function of color in the lives of birds can be divided into four general types: color associated with food, natal behavior, nesting activity, and egg recognition.

Color associated with food.—The field experiments with color are few, because as Lashley (1916) points out, it is virtually impossible to control outdoor illumination. This fact notwithstanding, some interesting findings have been made by field testing, and some inadvertent field situations have lent themselves to the appraisal of color discrimination among birds. As in laboratory experiments, the field tests for the most part showed association of color with food.

In the late 19th century, the destruction of yellow crocuses by sparrows in England was attributed to color choice, particularly since white and blue crocuses were spared (Shaw, 1876; Stokoe, 1877, and others). Tegetmeier (1877) immediately countered that he found all three kinds attacked by sparrows and that it was just a matter of learning since the yellow crocus was most common. W. White (1891) discussed briefly whether or not this attack on crocuses is antipathy for the color and concluded that it is "fondness" rather than antipathy that provoked the attack. So ends the case of the crocuses.

G. White (1877) also mentioned color awareness when he wrote that, "birds are much influenced in their choice of food by colour, for though white currants are a much sweeter fruit than red, yet they seldom touch the former till they have devoured every bunch of the latter."

The large number of plants having red berries may be the result of birds being attracted to them because of the red color, thereby scattering the seeds more widely, according to G. Hess (1951). The propensity of some birds for the red color is also reported by Pickens and Garrison (1931). Ruby-throated Hummingbirds (*Archilochus colubris*) visited colored flowers in a garden where red comprised 4 per cent of the available flower color. In three separate trials, 41, 33, and 38 per cent of the visits were made to red flowers, in the series of 12 possible color selections.

Lyerly, Riess, and Ross (1950) used one female Mexican Violet-eared Hummingbird (*Colibri thalassinus*) and generous application of statistics in selection tests of feeding bottles colored with fingernail polish. They found that only yellow was chosen significantly fewer times than red, green, and blue. Among the latter colors there was no statistical difference.

Marples (1933) fed colored peanuts to wild tits (*Parus major* and *P. caeruleus*) and nuthatches (*Sitta europaea*). He alternated colored with uncolored offerings and also placed the peanuts in concentric rings in some tests so as to eliminate position bias. His experiments were well conceived but poorly executed and inadequately interpreted since in each of five trials he changed the number of available colors and there is no short summary of his results. If one takes some of his test colors, using only those employed in all five tests, and rates these on an arbitrary scale of five points for first choice, four for second, and so on, the natural uncolored nut ranked first, the white nut second, the orange third, the green fourth, and the dark blue fifth. Red and purple were a poor tie for sixth position (table 1).

TABLE 1

COLORED PEANUTS FED TO CERTAIN BIRDS[1]

Color	Test number[2] 1	2	3	4	5	Points	Average
Orange	1(5)	2(4)	5(1)	7(–)	10(–)	10	2.0
White	5(1)	1(5)	1(5)	6(–)	2(4)	15	3.0
Green	2(4)	3(3)	6(–)	10(–)	7(–)	7	1.4
Dark blue[3]	7(–)	5(1)	4(2)	3(3)	12(–)	6	1.2
Purple	4(2)	9(–)	7(–)	6(–)	4(2)	4	0.8
Natural	3(3)	4(2)	2(4)	1(5)	1(5)	19	3.8
Red	6(–)	10(–)	9(–)	2(4)	9(–)	4	0.8

[1] Adapted from Marples (1933).
[2] Numbers outside of parentheses indicate order in which bird involved in test chose nut; numbers inside parentheses are points given for choice. Five points were given for first choice, 4 for second choice, and so on.
[3] Called Prussian blue in tests 3, 4, and 5.

Kalmbach (1943) also found that natural grains ranked ahead of artificially colored grains fed to a variety of birds under pen conditions. In summarizing, Kalmbach states, "On the basis of work done with English Sparrows [*Passer domesticus*] and House Finches [*Carpodacus mexicanus*], supported less emphatically by observations on pheasants, chickens, pigeons and waterfowl, most pronounced aversion manifests itself with respect to foods dyed with colors near the center of the humanly visible spectrum, in the yellow and green sectors." Although color can be evaluated accurately in each test situation, there appears to be no common pattern discernible in all tests or exact duplication in any two.

Psychological test associations with color.—A recent paper by E. Hess (1956) supports Kalmbach's findings in part. Hess examined the preferences of chicks and ducklings for objects of different colors in the laboratory. The results from his experiments with young domestic chickens supported Kalmbach's conclusions. Hess states, "For the chicks there is a bimodal preference to color, with one peak occurring in the orange region of the spectrum and a second peak in the blue region." Hess' ducklings and Kalmbach's Bobwhite (*Colinus virginianus*), however, presented opposite effects for the respective experiments. The relationship of bird behavior to color is seldom, if ever, without an aberrant situation. Schaefer and Hess (1959) attempted to imprint newly hatched domestic chickens with certain pure colors rated on the Ostwald color system. This laboratory experiment is somewhat involved and the details are not pertinent here. The results rate the following colors from best to poorest as imprinters: blue, red, green, orange, gray, black, yellow and white. A concluding remark indicates that the writers also found an inverse relationship between imprinting and "pecking for food objects of the same coloring."

Nesting conditions associated with color.—The aversion of Baltimore Orioles (*Icterus galbula*) to red strings in nest building (M. Smith, 1928) and the use of blue material to the exclusion of red and yellow by the Satin Bower Bird, *Ptilonorhynchus violaceus* (Edwards, 1920) are further observations on apparent color choice by birds in the wild.

A very interesting experiment in color awareness was conducted by S. Smith (1945) who constructed plastic fecal sacs which were placed on the rims of nests containing young birds. The natural inclination of the adults to keep the nest clean caused them to remove the false fecal sacs. In one set of five trials involving a pair of Meadow Pipits (*Anthus pratensis*), green, white, yellow, red and purple fecal sacs were removed in that order. In two of these trials the purple sac was ignored. Four similar trials at the nest of a Yellow Wagtail (*Motacilla flava*) showed the order of removal by the male to be yellow, purple, white, green and red. In the latter case the female removed only white artificial sacs. Smith (*op. cit.*) makes no sweeping claims for the data but states that there "may be a correlation between the colour awareness of a bird and the plumage colours of the species. . . ." I saw no such relationship in this or other color-awareness situations. Edwards (*op. cit.*) reported that the Satin Bower Bird which appeared to prefer blue objects with which it adorned its nest also had blue eyes.

Eggs and color associations.—McClure (*in* Kalmbach, 1943) states that in Mourning Doves (*Zenaidura macroura*), whose eggs are white, one "can color them any color you can conceive of" and the bird will continue, with only slight hesitation, to incubate the colored eggs. Not all birds are so undiscerning. Tinbergen (1953) in his field experiments with Herring Gulls (*Larus argentatus*) on egg recognition substituted colored eggs for the normal eggs in a series of nests. His conclusions were "that various colours have about equal releasing value, although there are indications that the natural colours are somewhat more stimulating than blue and yellow. Red, however, is definitely less stimulating, and even releases another response." Herring Gulls also refused to accept red eggs in the experiments of Goethe (1937).

The crux of the information discussed here is that there is no clear-cut pattern of reaction to color by various groups of birds or by birds in general. Each test seems to be conditioned not only by color but by attendant circumstances. Indeed the experimental situation may be the essential factor determining the color selected or rejected.

HOUSE WRENS AND COLORED NEST BOXES

My experiment was conducted to test whether House Wrens would discriminate among identically constructed nest boxes that were painted different colors. The type

Fig. 1. The five-can battery of colored nest boxes of House Wrens (*Troglodytes aedon*). Note the single top and ready access to box contents.

of nest box used in this experiment was a number 10 (2-quart) tin can with a removable wooden top and a circular entrance 2 inches in diameter. Some of these boxes were attached singly to fence posts for a general study of wrens and others were fixed together as a battery of five cans of assorted colors (fig. 1) with a single wooden top.

The male House Wren builds the major portion of the nest including the nest cavity. It remains only for the female to add the nest lining of fine materials before the eggs are laid. The male also carries nesting material to other likely sites nearby. The amount of nesting materials deposited in each box was used as an indicator of the preference for each box.

The tendency of wrens to be intolerant of other wrens nesting close by allowed for only one pair to occupy a single box in the battery of five boxes lined up side by side. Five colors were used: red, green, yellow, blue, and white. The Munsell (1942) ratings are as follows:

Hue (color)	Red	Yellow	Green	Blue
Value (brightness)	4	8	4	4
Chroma (saturation)	+10	8	6	8

These colors faded, often differentially, between years, and the batteries of nest boxes were repainted when the colors faded sufficiently to be detected by my eye. The position of any one color was rotated so that in five batteries every color occupied a different position in each battery. In any one year, 5, 10, or 15 batteries were placed in the field. Unfortunately not all the batteries were occupied by wrens in every year.

The results of 11 years' testing are shown in table 2. There was no statistically significant difference in choice among the various positions in the battery irrespective of color. Of the 98 boxes containing complete nests, red and green were obviously selected in preference over the remaining three colors. In order to test the statistical significance, if any, among the five colors, the Duncan multiple range test was applied (Duncan, 1955). This test compares each color with every other color. The results are presented in table 3. There was no difference between red and green, green and blue, blue and yellow, yellow and white. The differences among other combinations were

TABLE 2

COLORS AND POSITIONS SELECTED BY HOUSE WRENS IN NESTING BOX BATTERIES

Position	Red	Green	Yellow	Blue	White	Total
I	11	9	1	2	0	23
II	5	7	0	1	0	13
III	5	2	0	3	0	10
IV	7	6	1	7	2	23
V	13	7	6	3	0	29
Total	41	31	8	16	2	98

significant at levels ranging from .01 to .05. Since there was no difference between red and green, I suspected that old wrens that had nested in one of our many single green boxes in previous years might have returned and again used a green or a red box in the test battery. This happened in only one case, and the banded wren that had previously used a green box returned to nest in a blue box.

Table 3 deals with boxes in which a complete nest was made and at least one egg deposited. In a battery containing such a nest, other boxes also contained nesting material in varying amounts. The same holds for batteries where only a male nest was present and the other boxes had lesser amounts of nest material. In cases where the amount of nesting material could be rated on the basis of 5 points for the most, grading to 1 point for the least amount, 44 batteries were rated. As for the batteries containing complete nests, red and green were again preferred and showed no statistical difference at the .05 level in the preference (amount of use) between them by the wrens. The same was true among white, blue, and yellow, but these latter colors were preferred statistically less (.05) than red and green.

TABLE 3

STATISTICALLY SIGNIFICANT DIFFERENCES BETWEEN PAIRS OF COLORS OF NEST BOXES OF HOUSE WRENS

	Red	Green	Blue	Yellow	White
Red	....	0	.05	.01	.01
Green	0	....	0	.01	.01
Blue	.05	0	....	0	.05
Yellow	.01	.01	0	....	0
White	.01	.01	.05	0	....

One breakdown in the tolerance of the House Wren and also of the Tree Swallow (*Iridoprocne bicolor*) occurred in the nesting season of 1954 when a pair of each species nested in one of the batteries of colored boxes. The wren began nest building first and was followed in about three days by the Tree Swallow. The first egg was laid by the wren. On the following day the Tree Swallow laid the first egg of a clutch of four. The wren continued its laying until a clutch of six had been laid. Both females incubated, and all eggs hatched. The young of both species were fed without interspecific strife for six days when both nests were destroyed by a raccoon. I am confident that both sets of young would have fledged, as the birds had become spacially adjusted to each other. The Tree Swallow used the yellow box in position one and the wren used the red box in position five. In this case position was perhaps more important than the color of the box to the Tree Swallow because it nested after the wren had begun nesting. The distance between the entrances of the two end boxes was about 26 inches.

Wrens are usually double-brooded and frequently nest a second time in the same area if a site is available. Second nests of battery-using birds were sometimes placed

TABLE 4

COMPARISON OF COLOR OF ORIGINAL NEST BOX WITH THAT OF SECOND NEST BOX

Original nest	Second nest				
	Red	Yellow	Green	Blue	White
Red	8	....	1	....	....
Yellow	....	1	....	....	....
Green	2	....	3	....	....
Blue	1	....	1	2	....
White	....	....	....	....	1

in the same battery. When this occurred, there was a tendency to nest in the same box that had been used for the first nest. The boxes were cleaned by us as soon as the young fledged, but often renovation by the wren occurred in a day or two after fledging. The new nest was often only a thin layer of nest material over the first nest, if it had not been removed, plus a new nest lining. Of 20 known second nestings, 15 were in the same box as that used for the first nest (table 4).

In three cases, a pair of wrens nested simultaneously in two boxes. In all of these nestings, white was one of the "colors" involved (table 5). Since there was no difference between various pairs of colors (for example, red-green, green-blue, blue-yellow, and so on), the double nesting conceivably might have been one of color confusion. This, however, was not the case; instead it appeared to be a matter of position in the battery. In all instances, the two boxes were adjacent to each other, but the exact position was not recorded for one combination. Only one nest was successful in fledging its young, although young were hatched from one box in each of three pairs of boxes. The failures were not associated with the compound nesting effort.

TABLE 5

SIMULTANEOUS NESTING OF HOUSE WRENS IN BATTERIES OF COLORED NEST BOXES

	1944	1947	1951
Color	R–W	R–W	B–W
Position	5–4	4–3	?–?
Eggs	4–4	4–3	1–4
Young	4–0	3–0	0–2

The nesting success of 57 per cent for the general study where 336 single boxes were used is barely different statistically (chi-square test) from the 66 per cent recorded for the 98 colored boxes in the batteries. This can be accounted for, I believe, by reason of the fact that the color-test boxes were usually placed in the best possible sites in order to insure acceptability. This no doubt improved the chances for successful nesting as well.

DISCUSSION

This study adds another piece to a multi-unit mosaic on the role of color in the life of a bird. No attempt has been made here or elsewhere to put the pieces in order. There is no readily discernible pattern on the acceptance or rejection of given colors by birds, and often contradictory data present themselves. This apparent lack of conformity may lie in the difficulty of removing attendant variables associated with the testing situations. The relationship of brightness to color saturation is not always available for comparison in the various experiments nor are the colors always measured by the several color standards. Conditions in the wild are particularly difficult to control, yet it is here that the ecologist particularly wishes to resolve his problems.

The basic biology of color has wide interest and application. There is doubtless considerable evolutionary significance in the choice of color or association with color among birds and mammals and invertebrates as well. Yet this aspect of natural history is relatively unexplored. A knowledge of color preference or aversion could be used in animal control and management, particularly in control of pests by use of lethal baits or in discouraging nuisance activity or depredation by wild or feral animals. When the physiology, biochemistry, neurology, and ethology of the relationship of color to birds has been worked out, the widely scattered information now in the literature will add materially to the expanding picture of color biology.

SUMMARY

For 11 years, House Wrens (*Troglodytes aedon*) were given a choice of red, yellow, blue, white, and green nesting boxes. Each colored box was rotated in batteries of five boxes each. Of 98 nests constructed in the boxes, red and green were preferred and white was used least. There was no significant difference in the position of the accepted boxes in the battery. Wrens nesting for the second time within the year in a battery tended to use the same box occupied by the first nest. Three simultaneous nesting efforts within a battery were influenced by position rather than color, as the two nests were in each case adjacent to each other. A general study of wrens using single green boxes showed a 57 per cent fledging success, compared to 66 per cent in the colored batteries. This can be accounted for on the basis of better sites being used for the batteries.

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