STUDIES IN AVIAN COLOR REACTION

By A. L. PICKENS

Would hummingbirds show apparent color preferences in a group of varicolored flowers of uniform shape and size? The question is a fair one, and yet not amenable to test under ordinary field conditions. Accordingly, six paper flowers colored red, orange, yellow, green, blue, and purple, each with a vial of sugared water and all of uniform shape and size, were placed out for the Ruby-throats (*Archilochus colubris*) along a small glen.

During observations extending over a week, 175 visits were recorded as follows: Purple, 49; red, 47; orange, 31; blue, 22; green, 16; yellow, 10. Purple, red and orange were at times called upon for extra long drinks, and purple, red, orange, and blue were frequently hovered above for intermittent sipping; the order given shows the order of color for long drinks, sipping visits and sips, and thus the order of color selection is not affected thereby. Note how each color is set off against its complement: purple highest, and yellow lowest; red second highest, and green second lowest; orange third highest and blue third lowest.

The experiment began with a very red orange, but was changed on the second day to a more yellow orange, and visits fell from 12 to 7, and drinks from 10 to 2. The initial very reddish purple was changed on the third day to a mere violet; here the drop was from an average of 20 visits and an average of 15 drinks a day to 6 visits and 5 drinks. Curiously, on the day the intensity of orange was lowered, green gained, while on the day purple was modified blue gained. The red-kin relation here is apparently working, yet the increase in green and green-kin is not now explainable.

It was possible at times to check fairly well on the visits of a single individual by placing the group of flowers near its favorite perch. The first bird to begin patronizing the flowers had claim on a small area of jewel-weed, badly invaded both above and below by neighbors. It quickly found the purple bottle-flower and drank, then rose and flew past all the others to the red. It drank long, and once or twice stretched out on a large *Polymnia* leaf in front of the red bottle, its beak inserted into the sugared water as if yielding wholly to appetite and abandoning flight. It was probably rather hungry as a result of its territory having been so trespassed on by neighbors.

The bottles were removed to a neighbor's territory. They hung in a row: purple, blue, green, yellow, orange, red. Purple was examined, it being on the end, but the examiner was chased off by a neighbor; this happened again. A third trip, and purple was thrice sipped from, and the next four colors in the row were examined. A fourth trip, purple was again thrice sipped from; blue was skipped; green, yellow, orange, each sipped in turn, and red at the opposite end was drawn on for an extended draught; orange was examined again and the bird flew away, to return repeatedly. Here purple seemed the favorite for drinking, red, orange, and blue following in order; but while yellow was sipped from twice and green but once, green had seven additional examining visits without sipping, and yellow but two such. Still there was a rough approximation of the same surprising setting off of color against complement as noted before.

The totals for several other birds gave an order of red, orange, with blue and purple tying, yellow visited least, and green not at all. A bird when flying from a distance to the group of colors, selected red most often before which to make

the first pause; purple was a close second; orange, with half as many initial pauses as red, was third, while green, blue, and yellow followed in order. A tendency to select red-kin rather than green-kin colors is plainly apparent; that the colors are set off against their complements or approximate complements is indicated; in what way, however, is not indicated.

In contrast with the visual quest for food of hummingbirds is the tactile quest of the ducks. How would the color reactions of the two compare? A first test, in which a domestic drake was fed from colored servers, proved unsatisfactory, as mere contrast seemed to figure largely. White on blue, and brown on yellow, both highly valued by letterers for contrast, got excellent attention. A second test with vari-colored papers of uniform size fluttering on strings to simulate insects got better results. One drake, who as a duckling had shown a fear of red and orange, was first tested. One of the avoided colors (orange) was omitted, the chief desire being to test the bird's association of red and purple. Would it, like the hummingbird, associate the two as they are on the pigment wheel, or place them far apart as red and violet occur on the spectrum band.

Of the 100 times that the duck struck at or seized the imitation insects, yellow scored 41; blue, 22; purple, 15; green, 13; red, 9. Another drake without this complex as to red was tested. Much of its food showed red, orange, yellow and green colors, but from blues and purples it was protected. Of the first hundred strikes at the same colors, red received 31, and purple came next with 23, then blue, 17; yellow, 15; green, 14. In a second test with the same drake, purple came highest with 29, then red, 22; yellow, 21; blue, 17; green, 11. The drake that had feared red and orange, grouped purple, green and red as lows; the drake that had not, grouped together as highs red and purple, and left yellow and blue almost tying for second lowest with green.

Three other ducks have proved too nervous for experiment. All, however, react to the band of the spectrum, and seem to prefer the red end, nibbling at it curiously with the beak until its non-edible nature is fully impressed upon their psychology. Green is more neglected, perhaps an association that comes from being reared on a lawn. Other such associations are indicated: a drake after feeding on watermelon attempted to pick a painted rose off the surface of a bowl, while his mate after feeding on tomatoes reached up to pluck at a similarly colored Zinnia on the very tip of its stalk.

The ducks used in these experiments were the white Pekin variety of the domestic Mallard. The similarity of color reaction between representatives of such widely separated habit groups is noteworthy, but would not justify our concluding, for example, that the decorative objects selected by a Bower-bird would show a similar color relation. At least, it seems, there is offered here a field for additional experiment.

Let us graphically illustrate by initials the relation of the major colors as seen on the pigment wheel:

R
P O
B Y
G

Primitive forms of nearly all higher animal classes tend to assume gray, black, white, and brown colors. As development continues, assisted perhaps by environments of the blue-green of the sea and the greens of vegetation, there seems a tendency to assume colors from the lower half of the circle. Progress from here is often striking, and seniority appears to figure in the appearance of succeeding

colors. In beak and feet colors, bluish appears even in our Pied-billed Grebe (*Podilymbus podiceps*). With some weakness at green the next order carries us through yellow, orange and red, but the gap at purple is inadequately filled by the purplish-red of the feet of certain geese. Plumage starting in the blue-kin are advances in both directions. Even such high forms as the duck family affords seem limited to purple, blue, and green, save in badly toned down shades as in the so-called "red" of the Wood Duck (*Aix sponsa*). The flamingos and ibises attain red, and yellow lingers as a mere wash until found in the plovers. The orange gap is hardly filled before we reach true land birds. Our wood warblers, strong in yellow-greens, are weak at the purple gap; woodpeckers strong in red and yellow break down at blue and purple; our finches with brilliant reds, purples, blues, greens and yellows, break at orange. The orioles, with the brilliant Baltimore's orange, prophesy weakness for their group among blues and purples, and so on.

Let us take a whole family, found exclusively in the New World. The hummingbirds apparently followed the rule and developed from neutral browns, grays, whites and blacks a protectively green-colored type. Display plumage, striated and pigmented, developed. From available descriptions of the display plumage, it appears that 192 species show green in a form more or less ornamental rather than merely protective; 112 show blue, 60 purple, 82 red, 9 orange and 4 yellow. The graduated drop from green to purple may indicate the order of development. A rise at red would be expected from natural selection and red's general attraction, after which the decline is resumed. Thus these flower-loving birds trace a graph on our wheel backward to that of flowers which came from green, through yellow and red, to purple and are only now bridging the gap at blue, the mixture of blue and green found in certain feathers of the peacock being still unattained in the flowering plants. Certain flowers, in defiance of DeCandolle's xanthic and cyanic classification show blues and yellows grouped together. Can there be an undiscovered line of grouping through the green across this unbridged gap?

Seniority of color development, the building of tone on related tone, would explain many of the puzzling color harmonies we marvel at in nature. If such works naturally in jewels in the rough, why not in plumage? As to the designs formed, that is another problem; even Darwin confessed to worrying himself sick over the feather of a peacock. Nature working to evolve protective, yet ornamental colors near the bottom and left of our wheel seems to meet an aggressive force, that develops from those bottom colors, step by step, the more showy colors near the top and right.

Dr. J. C. Lewis in "Some Considerations on Sight in Birds" (Emu, 15, 1916, p. 224) notes briefly some objection to the Young-Helmholtz theory that the color vision of birds is limited to red and green, or combinations of these. The present experiments indicate that some birds at least see colors also in relation to red and green. Grant, then, a mating selection by a red-loving female, ultramarine would be preferred to blue, and purple to ultramarine, though both might be seen by the bird as varying shades of red because of the red pigment contained. Fortunately the females of many species have ever been willing to lower their high ideals and desires to meet and accept the poor approximations that were available. The color ideal of many birds seems to lead to colors that contrast with the ubiquitous green.

Greenville, South Carolina, July 29, 1935.