EXPERIMENTS ON THE COLOR PREFERENCE OF BLACK-CHINNED HUMMINGBIRDS

By FRANK BENÉ

In the notes of field workers and in the remarks of casual observers, the statement is frequently made that hummingbirds are partial to red objects and flowers. Red is regarded as the predominant color in hummingbird flowers, implying thereby that in the Trochilidae there is an inherent attraction for red. The purpose of this paper is to inquire into the validity of this assumption.

Experiment 1.—In Phoenix, Arizona, on March 14, 1940, the writer tested the color preference of an adult female Black-chinned Hummingbird (*Archilochus alexandri*) that since February 26 had been visiting and feeding from amber-colored honey glasses at intervals during the day of from 15 to 45 minutes. When deprived of these feeders, she would visit the lilac-colored blooms of the butterfly bush (*Buddleia farquhari*), and more often the orange corollas of an *Aloe*, but she ignored the profusion of orange, scarlet, maroon, and yellow nasturtiums. This bird had probably been feeding from the honey glasses in the previous year, for on the day of her arrival from the winter range she flew to the honey glass the moment I placed it at her disposal.

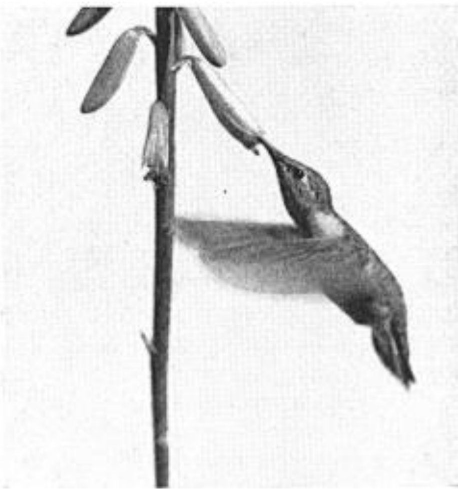

Fig. 64. Female Black-chinned Hummingbird probing *aloe*; bird used in experiment 1.

Five one-ounce wine glasses were filled with syrup having a concentration of two teaspoonfuls of sugar in one ounce of syrup. The syrup in one glass was left uncolored while the syrup in the remaining containers was colored with tasteless food dyes, such as are used in pastry cookery. No more than two feeders were exposed to the bird at one time, so that on each visit to the feeders she had to choose one of two, thus indicating her color preference. Placed in a shaded spot, the colorless, yellow, orange, and green feeders were exposed for five trips and the red feeder for twenty trips. Obviously, red had an exposure advantage four times more than any other single feeder. The bird's choice is given in the following table:

TABLE 1
Color preference of female adult Black-chinned Hummingbird

Order of trips to feeders	Time of arrival	Reaction
		(Choice of red and colorless syrup)
1	8:22	Colorless chosen
2	8:41	Colorless chosen
3	8:52	Red chosen first, colorless second
4	9:02	Colorless chosen
5	9:17	Colorless chosen
		(Choice of red and orange)
6	9:38	Red chosen first, orange second
7	9:51	Red chosen
8	10:13	Orange chosen
9	10:25	Orange chosen
10	10:38	Orange chosen

Order of trips to feeders	Time of arrival	Reaction
		(Choice of red and yellow)
11	11:19	Yellow chosen
12	11:37	Red chosen first, yellow second
		(Choice of red and green; red feeder is placed on stand previously occupied by colorless, orange, and yellow feeders. Green feeder is placed on stand previously occupied by red feeder.)
13	12:12	Green chosen
14	12:27	Green chosen first, red second
15	12:40	Red chosen
16	1:14	Green chosen
17	1:24	Green chosen
		(Choice of red and yellow)
18	1:49	Yellow chosen
19	2:09	Yellow chosen
20	2:29	Yellow chosen

If we assign to first choice a value of 3, to second choice, 2, and give red one-fourth value by reason of its advantage of exposure, the colors have the following values of preference:

	Colorless	Yellow	Green	Orange	Red
First choice	12.0	12.0	12.0	9.0	3.75
Second choice	2.0	2.0	....	2.0	.5
Total value	14.0	14.0	12.0	11.0	4.25

Of significance is the bird's reaction to the feeders, which is not given in detail in the table. On the third trip the bird paused at the red syrup, dipped her bill into it, then quickly withdrew, moving over to the colorless feeder to drink contentedly. The bird appeared quite satisfied with the colorless, orange, yellow, and green feeders, preferring these to red, but she was impelled to sample red syrup on the third, sixth, seventh, twelfth, and fifteenth trips.

Because the red feeder received such scant attention for the first twelve trips, the experimenter was convinced of the bird's indifference to red. Therefore, to put red at an advantage over the other feeders, he placed the red feeder on the stand previously occupied by feeders other than red. Also, to detract the bird from the yellow feeder, a green feeder was substituted for the yellow, after the yellow feeder was exposed for only two trips (later yellow was given three more exposures). But even this change failed to draw the bird to red, for up to and including the twentieth trip the bird hardly visited the red syrup.

Experiment 2.—On April 5, 6, and 8 of 1941, a second experiment was carried out. This time the subjects were two male adult Black-chinned Hummers. Unlike the female of the previous experiment, these birds preferred sugared water to commercial honey. Before participating in the experiment, they had been feeding regularly from syrup glasses, one bird since March 24, the other since March 27. Before this the birds would sample vials of honey hidden in beds of nasturtium. As long as the vials were disguised with nasturtium blooms so that the color of the contents was concealed, the birds showed no marked preference for one over the other. But when the disguise was removed, they unmistakably chose the colorless syrup and rejected the amber-colored honey solution. Between feedings from the syrup glasses, which the birds were in the habit of visiting, they would indiscriminately probe the maroon, scarlet, salmon pink, yellow, and orange nasturtiums. Occasionally they fed from the white flowers of the shrimp plant (*Beloperone guttata*) of which two small bushes were available. Frequently they visited the white blossoms of orange and grapefruit trees and the pink-white blossoms of the lemon tree. Before these flowers were in bloom, they had been visiting the *Buddleia*.

Two new coloring dyes, violet and blue, were added to the battery used in the experiment of the previous year, so that a total of six colors was available to the birds. No colorless syrup was used, because in a preliminary test the birds would ignore the colored feeders, giving exclusive patronage to the colorless syrup from which they had been trained to feed. Altogether six colored feeders, displaying all the colors of the solar spectrum, were arrayed before the birds at one time, as shown in the accompanying illustration (fig. 65). From time to time the position of the feeders in the battery was changed to prevent the birds from forming habits of position.

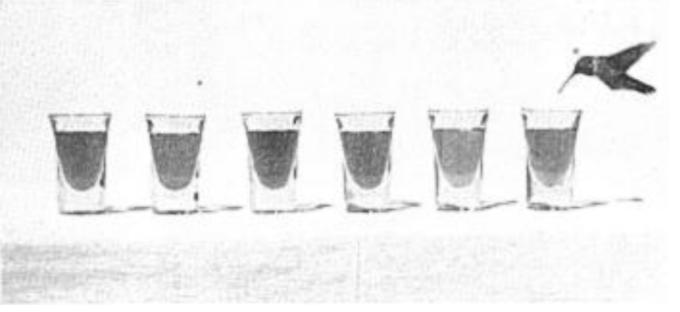

Fig. 65. Battery of colored feeders (green, red, violet, blue, yellow, orange) used in experiment 2. Adult male Black-chin is sampling orange syrup.

Unlike the female bird of the first experiment, these males were extremely wary of the colored feeders, so that it was necessary to continue the experiment over three days until a total of twenty-six visits was made. The experimenter sometimes had difficulty in distinguishing the individuals, and for this reason we shall deal only with their collective choice of colors, as shown in table 2. The same procedure of weighting choices was used as in the first experiment.

Comparing the color preference of the female Black-chin with that of the males, we note that in both cases yellow ranks high.

TABLE 2

Color preferences of two adult male Black-chinned Hummingbirds, showing choice of colors made on twenty-six trips. Choices weighted as follows: first, 3; second, 2; third, 1.

	Yellow	Orange	Red	Blue	Violet	Green
		April 5				
First choice	3	6	9	3	9	0
Second choice	0	6	2	4	0	0
Third choice	1	1	0	0	0	0
Total	4	13	11	7	9	0
		April 6				
First choice	24	6	0	0	0	3
Second choice	4	2	0	0	0	0
Total	28	8	0	0	0	3
		April 8				
First choice	3	6	0	3	0	3
Second choice	2	2	0	0	0	0
Total	5	8	0	3	0	3
Grand total	37	29	11	10	9	6

Unlike the female, these males were very eclectic and capricious in their choice of colors. One of them had difficulty making up his mind on April 5, for he sampled three different feeders on each of two trips. The other tried two colors on each of the four trips on the same day. After this their minds were pretty well made up, for they seldom sampled more than one feeder on a trip. Also, after April 5 they were inclined to be more constant in their choice.

Fig. 66. Male Black-chin in flight.

Fig. 67. Male Black-chin drinking from colorless syrup glass.

At the time of the experiment, green and yellow predominated in the garden flora. Yellow blooms of jasmine hung conspicuously from three floral fences. The reds and yellows among the nasturtiums were equally abundant.

Color preference of Ruby-throated Hummingbird.—Using six uniform-sized sugar-water artificial flowers, Pickens (1941:100) found that Ruby-throated Hummingbirds (*Archilochus trochilus*) visited the artificial flowers in this order, according to frequency: violet, 46; red, pink, and white, each 37; green and blue, each 36; yellow, 34; orange, 32; maroon, 29. The number of birds used in the experiment is not given.

If red and maroon are grouped under "red," his birds exhibited a decided preference for red, with violet second. Of further interest in the investigation are the reactions of individuals to the color of flowers. Pickens writes: "A single Ruby-throated Hummingbird busy with a large *Abelia* clump conspicuously neglected some scraggly red salvia-like plants and a violet *Achimenes* growing near by." Another hummingbird (presumably a ruby-throated), "lantana-trained perhaps to look on red as the color of a dying flower, rose from its lantana clump to examine a red artificial flower but was never seen to drink."

COMPARATIVE DATA

It is interesting to note that the Ruby-throated Hummingbirds were most attracted to red and violet, which are located at the extreme ends of the solar spectrum comprising violet, indigo, blue, green, yellow, orange, and red, whereas the Black-chinned Hummingbirds preferred yellow, in the middle of the spectrum. These differences in color preference force us to ask whether color preference in animals below man is governed by the light properties of the object itself, or determined by the structure of the rods and cones in the retina, or conditioned by individual experience and training. Answers to these questions would provide some basis for accepting or rejecting the assumption that partiality to red is a trait of the species, or of the family of hummingbirds. We turn to comparative data obtained in the investigation of color reactions in animals other than hummingbirds.

Color sensitivity.—In experiments to test the color sensitivity of the pigeon and domestic chick, Watson (1915) found the limits of spectral sensitivity of the pigeon to be approximately 420 and 712 mμ; and for the chick 400 to 707.5 mμ. The human eye is sensitive to monochromatic lights from 400 to 760 mμ. If we may accept the figures for the pigeon and chick as true of the hummingbird, then the hummingbird is sensitive to all colors of the spectrum within the wave lengths given above.

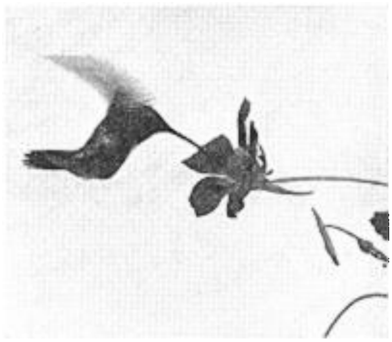
Fig. 68. Adult male Black-chin probing red nasturtium.

It is generally agreed that for the light-adapted eye the maximal sensitivity lies in the yellow-green region, from 580 mμ to 530μ (Woodworth, 1938:539-550). If the rods and cones were the sole factor in determining color preference, then the light-adapted animal would be most attracted to yellow-green, not red.

Color constancy.—Whether animals perceive the object color (the way an object absorbs and reflects light that strikes it) or the stimulus brightness (light intensity or illumination of the object) has been a subject of much investigation, but chiefly with humans as subjects. Locke (see Woodworth, 1938:605) found that of four Rhesus monkeys and five human adults tested, monkeys react more to object colors than to stimulus brightness. Also, his Brunswick ratios show that monkeys react more to object colors than do humans:

Human adults: .10, .13, .19, .23. Monkeys: .47, .53, .59, 65.

Brunswick ratio = (R—S)/(A—S), where A = a numerical value for the object; S = a numerical value for the stimulus brightness; R = a numerical value for the response or actual match (of colors).

That this response to object color is a function of the cerebral cortex and hence can be conditioned by training has been demonstrated by a number of investigators of animal behavior.

Kohler (1917) experimented with seven- to eight-month old chicks. After training the hens to pick grain only from the darker of two sheets of paper, both under the same moderate illumination, he placed the darker paper in direct sunlight, leaving the lighter paper in the weaker illumination. The hens continued to pick up the grains from the dark gray paper, though it was reflecting more light than the white paper. The brightness ratio of grain to background remained unchanged.

Katz and Révész (see Woodworth, 1938:606) stained grains of rice a strong yellow and trained hens to pick up white grains from the mixture. Then with strong yellow light they illuminated the white grains placed on a white ground. Without hesitation the hens picked up the grains which were reflecting the strong yellow light. The yellow grains were not yellower than the ground.

Burkamp (see Woodworth, 1938:606) was interested in investigating (1) the color sense and (2) the color constancy of aquarium fishes (*Cyprindes*). His procedure was to train the fish to feed from a trough of a certain color and then test the fish to find whether it was able to pick this color from a collection of grays and other colors. The colors were illuminated with light of various intensities. His results show that (1) the fishes were definitely positive in the selection of colors, except for confusing between red and yellow, and that (2) they picked out the object color in very dim light better than can the human observer.

CONCLUSIONS

1. Black-chinned hummingbirds are not attracted to red more than to any other color.
2. Color preference may be conditioned by training, as when a hummingbird trained to feed on colorless syrup remains constant to it, even when the colorless syrup is placed among feeders containing syrup of different colors.
3. There is no justification to regard partiality to red as though it were a phylogenetic trait of a species of hummingbird or of the family Trochilidae itself.

LITERATURE CITED

Köhler, W.
1917. Die Farbe der Sehdinge beim Schimpausen und beim Haushuhn. Zeit. Psych., 77:248-255.
Pickens, A. L.
1941. A red figwort as the ideal nearctic bird-flower. Condor, 43:100-102.
Watson, J. B.
1915. Homing and related activities of birds. Carnegie Inst. Washington, publ. 211:87-104.
Woodworth, R. S.
1938. Experimental Psychology (New York, Henry Holt and Company), xi+889 pp.

Phoenix, Arizona, July 1, 1941.