

ANNA'S HUMMINGBIRDS TRAINED TO SELECT DIFFERENT COLORS IN FEEDING

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This investigation concerns color selection in the feeding behavior of Anna's Hummingbird (*Calypte anna*). In a study of the Black-chinned Hummingbird (*Archilochus alexandri*) in Arizona, Frank Bené (Condor 43:242, 1941) concluded that "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." But Bené gave little evidence other than this for the role of training in color preference of hummingbirds.

In our study, the hummingbirds were given syrup made by boiling water with the appropriate amount of table sugar for a few minutes. In most of the experiments, the syrup was given in 55 ml bottle feeders. In the last experiments, 72 ml test tube feeders were used. The birds fed at the opening of a bent piece of glass tubing from the bottom of the feeder. The syrup was colored by the addition of ordinary, tasteless food dyes.

The feeders were hung beside each other on a branch of a rubber plant just outside a large glass door through which the hummingbirds could be seen easily when they visited the feeders. The relative position of different feeders was changed systematically throughout most of the tests reported here. The feeders were regularly visited by one male and two female Anna's Hummingbirds in our garden. The following results were obtained.

Color had to be associated with food reinforcement to continue to attract the hummingbirds. A feeder containing only red water placed beside a red solution of 50 per cent sugar was ignored, although all the sugar solution was taken within five days. When the per cent of sugar solution in the feeder containing sugar was progressively reduced during each test, the hummingbirds continued to take the solution until it was reduced to only one part of sugar to eight parts of water. This very dilute solution was still untouched after 15 days, although the hummingbirds were regularly seen in the garden. A feeder with a high concentration of sugar was then restored, and the birds finished all 55 ml within a week.

Anna's Hummingbirds generally selected position over color of feeder when the two feeders contained equal concentrations of sugar (table 1). The outside

TABLE 1. Effect of position and color of feeders.

To date	Outside position	Amount taken		
		red	blue	yellow
27 Oct.	Red	all	2/3	—
5 Nov.	Blue	3/4	all	—
13 Nov.	Red	all	2/3	—
22 Nov.	Blue	3/4	all	—
29 Nov.	Yellow	3/4	—	all
7 Dec.	Red	3/4	—	all

TABLE 2. Effects of sugar concentration, color, and position of feeder.

To date	Position and concentration				Amount taken	
	outside	inside	outside	inside	outside	inside
15 Dec.	Red	20%	Red	50%	3/4	all
22 Dec.	Red	50%	Yellow	10%	all	none
24 Dec.	Red	10%	Yellow	50%	slight	all
4 Jan.	Blue	50%	Yellow	10%	all	slight
11 Jan.	Blue	10%	Yellow	50%	none	all
16 Jan.	Blue	50%	Yellow	10%	all	none
20 Jan. ^a	Yellow	10%	Blue	50%	none	all
26 Jan.	Blue	50%	Yellow	10%	3/4	none

^a Positions reversed after blue one-half gone.

position, which was the preferred one, was toward the tip of the branch supporting the feeders and was a little farther from the window (about four feet away) and therefore from the observers. Probably the convenience of approach by the hummingbirds was not significantly different for either feeder since the birds usually came in to feed in such a way as to be about as close to one feeder as to the other. Only Anna's Hummingbirds were involved.

Anna's Hummingbirds selected feeders with higher sugar concentration over color and position of feeder (table 2). This was true in every case tested.

Anna's Hummingbirds could be readily trained to select specific colors. This was true, irrespective of intensity of color, since these same individuals could also be trained to select or to avoid colorless sugar solution, presented with feeders containing blue, yellow, or red sugar solution.

The period of this experiment was 26 January-1 April, 1962, at a season when no other species of hummingbirds were in our garden. The birds were trained to a given color by having that color with the sugar solution in it, while the other three feeders simultaneously present contained only water of different colors. The periods of training before testing were, in order: blue (10 days for one test series and 30 days for another), yellow (2 weeks), red (4 to 5 days), and colorless (2 weeks).

After the hummingbirds were assumed to be well trained, all four bottles were filled merely with different colored waters, and the visits to each colored feeder by the Anna's Hummingbirds were observed and recorded (table 3). The total observation time in minutes for the four test solutions, following the training period, was 312 minutes for blue, 190 minutes for yellow, 83 minutes for red, and 317 minutes for colorless. The colorless feeder contained uncolored water either with or without sugar. The position of the color to which the birds were trained was shifted just before each test series began.

There was a tendency to persist in selection of a given color. After the preceding experiments were finished and just after the Anna's Hummingbirds had been trained to feed from colorless solution, we discontinued using bottle feeders and put up a row of

TABLE 3. Tests for selection of color to which trained.

Training color (with sugar)	Visits to the test colors (without sugar)			
	blue	yellow	red	colorless
Blue	35	12	8	3
Yellow	1	27	0	0
Red	6	6	22	0
Colorless	9	0	2	19

five test-tube feeders. Each test tube contained a differently colored sugar solution (red, blue, yellow, or green), except for one that contained colorless sugar solution. Both Anna's and Black-chinned Hummingbirds that had just arrived in their migration were involved in these tests. Each tube was emptied by them before the next one selected had been more than half emptied. This result demonstrated a tendency to persevere on a given color before shifting to another color. This whole experiment was repeated a second time, with similar results regarding tendency to persist on a given color, although the order of colors selected varied slightly with change in relative position of colors in the second experiment. In these two experiments, yellow and green were selected least often, while red and blue were selected most often.

Exploratory shifts to different colors were seen. Direct observation of the different feeders showed that a hummingbird would sometimes take a sip from more than one feeder before settling down to feed for a more prolonged time at another feeder. Such shifts were seen for both species of hummingbirds visiting the feeders at this period of our study.

A natural preference for red may sometimes be manifested. In the spring of 1967, five years after we had discontinued feeding the hummingbirds, the same series of test-tube feeders and colors as described above was put out in the garden. Presumably there were now no hummingbirds in the neighborhood trained to artificial feeders. A female Anna's that

came to the feeders was seen to select the red feeder over blue, yellow, green, and transparent feeders in 15 out of 15 different series of visits, over a period of a few days during which the position of the red feeder was shifted each day.

Discussion. Our results can be related to the feeding behavior of hummingbirds at flowers in nature. Flower nectar is little more than sugar water. Conditioning to position of a food source is related to learning the location of plants that have recently come into bloom and have a good nectar flow. It is quite possible that Anna's Hummingbird might be adapted to learning to feed at certain colors, perhaps such as red, faster than at other colors, perhaps such as green. However, the ability to learn to shift readily from one blossom color to another is adapted to the differences in color of favorite flowers of this species of hummingbird in nature, such as the red blossoms of the red-flowered gooseberry (*Ribes speciosum*) and the yellow blossoms of the tree tobacco (*Nicotiana glauca*). The tendency of hummingbirds to persist in coming to a given color that has proved rewarding assures that the birds will continue to exploit a given species of plant so long as it gives a good nectar flow. Such persistence is balanced against the exploratory tendencies of the hummers which increases the probability that flowers of different species of plants will be discovered to be profitable just as soon as they begin to have a good nectar flow.

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FIRST RECORD OF THE TURKEY *MELEAGRIS GALLOPAVO* FROM THE PLEISTOCENE OF MÉXICO

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While studying the bird collections of the Department of Vertebrate Paleontology, American Museum of Natural History, I found a proximal end of a right humerus (AMNH 6823) of the Wild Turkey (*Meleagris gallopavo*). The specimen was collected in 1928 by B. Brown, one mile east of Arizpe, 60 miles southeast of Cananea, Sonora, México; the age is recorded as "L. Pleistocene?" According to the accompanying label, the fossil humerus was associated with "*Bison* ref. *alleni*, *Equus* cf. *tau*, *Serridentinus*, & *Archidiskodon imperator*," thus indicating the age is very late Pleistocene (approximately Wisconsin).

No records for *M. gallopavo* are known from the Pleistocene of México (Brodkorb, Bull. Fla. State Mus. 8:335, 1964), although another species, *M. crassipes*, has been described from San Josecito Cave, Nuevo León (Miller, Condor 42:154-156, 1940). *Meleagris crassipes* was considerably smaller than *M. gallopavo* as was *M. richmondi* of the Pleistocene of California (Shufeldt, Trans. Conn. Acad. Arts Sci. 19: 67, 1915). *Meleagris leopoldi* (Miller and Bowman, Wilson Bull. 68:42-45, 1956) is based on the relative position of the tarsometatarsal spur cone and consequently cannot be compared with AMNH 6823. The collection of fossils united by Brodkorb (*op. cit.*, p. 325) under the name *M. alta* (= *M. superbus* and *M. celer*) has a size range encompassing AMNH 6823. Species limits in these turkeys are uncertain because of the large amount of variation in shape and

size (including sexual differences). It is highly unlikely that the specimen reported herein represents *M. alta*. The fossil is referred instead to *M. gallopavo* for the following reasons: (1) the fossil was compared with a series of 10 humeri of *M. gallopavo* from the Pleistocene of Florida and was found to fall within the range of variation of the series, (2) *M. gallopavo* had a broad Pleistocene distribution and is known to occur in Sonora today, and (3) the fossil is very late Pleistocene in age and therefore almost assuredly is *M. gallopavo*.

The Sonora locality for AMNH 6823 suggested the possibility of its being a new locality record for *Parapavo californicus*. Therefore, through the courtesy of Hildegard Howard, the Sonora specimen was compared with skeletons of *Parapavo*. Dr. Howard informed me (personal communication) that the pneumatic foramina within the pneumatic fossa "occupy a smaller space in AMNH 6823; in *Parapavo* they not only tend to extend farther beneath the tuberosity, but they occupy more space laterally. In my two *M. gallopavo* specimens the foramina seem to occupy the smaller area comparable to AMNH 6823." Howard also noted that AMNH 6823 differs from her specimens of *M. gallopavo* in the development of the prominence of the distal extension of the head on the anconal side, but great variation in this character was found in the Florida humeri I examined.

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