

# COLOR PREFERENCES OF THE XANTHID MUD CRAB *RHITHROpanopeus harrisii*<sup>1</sup>

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## ABSTRACT

Male and female xanthid mud crabs, *Rhithropanopeus harrisii*, when subjected both to paired and to simultaneous-combination color tests, exhibited nearly identical preference patterns for black, yellow, green, red, blue, and ultraviolet colors (listed in order of choice), although some individual variation occurred. Further investigations into the statistically significant reactions to blue and ultraviolet colors by both sexes is warranted.

Although decapods are known to possess color discrimination, few have been subjected to color-preference tests (Waterman, 1961). Little is known regarding color preferences of the xanthid crab, *Rhithropanopeus harrisii* (Gould), which abounds in Chesapeake Bay (Ryan, 1956) and in the brackish waters of the Patuxent River adjacent to Solomons, Maryland. Experiments were performed to see if this crab could discern between colors, whether there were color preferences, and whether they were sex specific.

## TEST ANIMALS AND EXPERIMENTAL PROCEDURES

During the period 13 to 17 July 1962, five male and five female *Rhithropanopeus harrisii* were tested to determine if they exhibited color preferences when subjected to seven colored lights (hereafter called colors): black (darkness), white, red, yellow, green, blue, and ultraviolet. Between 4 and 17 September 1962, additional specimens (3♂♂, 3♀♀) were subjected to tests where all seven color conditions were presented simultaneously to corroborate the original color-combination test results.

Crabs 10.1–15.3 mm in carapace width were collected from trays of oysters located at the end of the 250 m Chesapeake Biological Laboratory pier which extends into the Patuxent River. Prior to testing, all specimens were kept alive separately in plastic ice cube trays in running water of the same temperature and salinity (8–18‰) as that pumped from the Patuxent River. Food, except during test periods, consisted of bits of oysters or soft-shell clams.

Test chamber for the July experiments consisted of an oblong 56.8-liter aquarium with glass sides and slate bottom, darkened on all sides to prevent entry of outside light. A cardboard placed vertically across the center of the aquarium extended to within 61 mm of the bottom, to divide it into two smaller and nearly equal chambers. No substrate was employed. A constant flow of unfiltered Patuxent River water was maintained by plastic tubes entering the aquarium along either end of the divider. Siphons, one at each end of the aquarium, maintained a 61-mm water depth. This water-circulation pattern seemed least likely to cause the crabs to learn to prefer one segment of the aquarium over that of another. Each test chamber was covered by a removable light source in the form of a 30.5-cm-square, 27.9-cm-high pyramidal cardboard enclosure containing a 100-watt incandescent bulb. Light from this source passed through a 19-cm circular hole at the base of the enclosure containing the light and through one of several color filters. Color filters were made from colored cellophane often several layers thick. Light intensity for all filters was standardized to that level passing through the blue filter.

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July experiments consisted of placing one each of the five male or five female crabs into the small color-overlap zone, produced at the base of the cardboard divider in the oblong aquarium by any two color-test combinations. Twenty-one combinations (i.e. black with yellow) of the seven original colors were conducted, each tested 10 times, for a total of 1,050 tests per sex (5 crabs) (Table 1). Each test was of a five-minute duration. Pre-experiment trial observations noted that crab "selection" of one color or another occurred in less than one minute. The color in which the crab was found was considered the "chosen" color. At all times,

TABLE 1

*Two color preference and avoidance reactions exhibited by male and female mud crabs tested summer, 1962. Lower half of table indicates preference, upper half avoidance, 50 tests for each color combination*

Color	Sex	Color							Ultra-violet	Total Avoidance
		Black	White	Red	Yellow	Green	Blue			
Black	M	—	2	7	19	19	8	4	59	
	F	—	4	15	22	10	11	6	68	
White	M	48	—	26	27	31	30	13	175	
	F	46	—	23	38	34	28	8	177	
Red	M	43	24	—	31	30	14	8	150	
	F	35	27	—	25	31	20	5	143	
Yellow	M	31	23	19	—	16	18	12	119	
	F	28	12	25	—	33	22	7	127	
Green	M	31	19	20	34	—	15	13	132	
	F	40	16	19	17	—	26	11	129	
Blue	M	42	20	36	32	35	—	24	189	
	F	39	22	30	28	24	—	13	156	
Ultraviolet	M	46	37	42	38	37	26	—	226	
	F	44	42	45	43	39	37	—	250	
Total Preference	M	241	125	150	181	168	111	74	1050	
	F	232	123	157	173	171	144	50	1050	
Grand Total		473	248	307	354	339	255	124	2100	

to eliminate a learning factor, test-color pairs were selected randomly and altered (i.e. red could occur in one end of the aquarium during combination tests 1, 4, 7, 8, 9 and in the other during tests 2, 3, 5, 6, and 10) between ends of the tanks to further eliminate preference to some peculiarity in one end of the test aquarium. Specimens were likewise tested randomly. The 2,100 tests were conducted between 0900 and 2300 hr, with the preponderance being between 0900 and 1700 hr. (0900, 100 tests; 1000, 190; 1100, 260; 1200, 220; 1300, 180; 1400, 210; 1500, 210; 1600, 170; 1700, 120; 1800, 70; 1900, 70; 2000, 100; 2100, 110; 2200, 80; 2300, 10).

A circular 22.9-cm glass tank 30.5 cm high was darkened throughout with black paint and served as a test chamber for the second series (September) of color observations. A 10-cm water depth was maintained by a circulating water system entering down the center of the tank and passing up through a plastic disk which had been drilled with 3-mm holes, situated 6.1 cm off the bottom. Water was siphoned off from near the center of the tank. A conical overhead enclosure was divided by cardboard dividers into six pie-shaped chambers. Each pie-shaped

wedge contained a color identical in composition to the July experiments (ultraviolet being excluded because of bulb size).

Round-tank tests consisted of introducing the specimen at the center of the tank, at a point where all of the colors overlapped and observing the crab's position, relative to a color, after five minutes. The top, which contained the colors, was rotated randomly after each test to reduce chamber-cue bias. Thus, white may have been over position 1 during test 1, but over position 5 during test 2, etc.

Chi-square analyses were performed to see if the patterns of color choices between sexes were different and if some colors were selected more than others. Water temperatures and salinities were recorded throughout both test periods and ranged between 25.3–26.7°C and 12.9–13.6‰ for July and 24.5–25.8°C and 15.3–16.0‰ for September.

#### RESULTS

*Aquarium tests.*—Male and female *Rhithropanopeus harrisi* exhibited nearly identical color preferences (Table 1), which were, in order of preference: black, yellow, green, red, blue, white, and ultraviolet. Slight variations were attributable to specific individuals who, no matter what color combination was presented, moved either to the right or left.

As expected, a highly significant positive reaction to black (Table 1) was expressed by both males (241 of 300 tests) and females (232 of 300) (Table 2).

TABLE 2

*Chi-Square Analyses of Positive reactions within and between Male and Female Mud Crabs to Individual Colors and to all Colors, 1962*

Color	Within Sexes				Between Sexes	d.f.
	Male X <sup>2</sup>	Significance	Female X <sup>2</sup>	Significance		
Black	110.41	*	89.65	**	0.17	1
White	0.33		9.72		0.02	1
Red	0.01		0.65		0.16	1
Yellow	12.81		7.05		0.19	1
Green	4.32		5.88		0.03	1
Blue	20.28	**	0.48	**	4.27	1
Ultraviolet	77.01	**	13.33	**	4.65	1
Total	225.17	**	126.76	**	9.49 <sup>1</sup>	7

<sup>1</sup>Not significant  $P \approx 0.2$ .

Unexpectedly, yellow was second choice by both males and females. However males, when subjected to a yellow and green choice combination between 0900–1200 hr and 1500–1700 hr, moved toward the yellow more often than toward the green color, whereas at other times of the day, yellow and green were split choices. Females during the same hours exhibited just the reverse reaction to a choice between yellow and green. While it is known that coastal waters generally have their maximum transparency in the yellow-green portion of the spectrum (Hill, 1962), it was not known whether, locally, yellow or green were the wave lengths that filtered down to the crabs, during the 1000–1700-hr portion of any sunny summer day, to influence their behavior. Red was chosen more often than blue, a reverse of what one would have expected for these shallow-water-inhabiting crabs, where blue colors characteristic of the deeper water layers should have filtered down through the water column to them rather than the red. Why blue was chosen less often by males (Table 1) than by females needs additional experi-

mentational investigation. White (a mixture of all colors) was, contrary to expectations, sixth in color preference, despite the fact that *Rhithropanopeus harrisi* may be observed moving actively about in its natural environment during daylight hours. Males and females both exhibited a highly significant avoidance of ultraviolet light.

*Round-tank tests.*—Round-tank tests corroborated the results achieved by the two-color-aquarium choice tests. The same sequence of color preference—black, yellow, green, red, blue, white, and ultraviolet—was noted for each sex. Males and females also exhibited their peculiar yellow-green reverse phases in these tests, as they had done in the earlier ones.

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