Color selection of nesting material by Killdeer.—The Killdeer (*Charadrius vociferus*), a common ground-nesting bird throughout North America, demonstrates unique behavioral patterns relating to nest building. Many researchers have noted that Killdeer nests frequently contain a large amount of white material (Stockard 1905, Tyler 1913, Allen 1932, Butler 1937, Miller 1949, Bunni 1959). The objective of this research was to test experimentally whether Killdeer actually select white material for their nests. This quantification must precede any consideration of the presumed functions of the behavioral trait.

Selection of substrate for nest sites by Killdeer varies considerably. Mace (1971) describes the most frequent habitats for Killdeer nests as: (1) bare cultivated fields, (2) planted fields, (3) open fields with dirt or grass, and (4) asphalt. For the purposes of this work, substrate type was classified into four categories: (1) white gravel, (2) fields with little or no vegetation, (3) fields with some vegetation, and (4) fields heavily covered with vegetation.

In North Carolina egg-laying begins early in March and continues through June. I put 20 Killdeer nests in Mecklenburg Co., North Carolina through three tests during the breeding seasons of 1974 and 1975. Small wooden sticks (10mm × 3mm × 3mm), used to test for the possible selectivity of nesting material, were spray-painted either black or white with a nongloss enamel. Pilot studies on three nests during the spring of 1974 showed that Killdeer would use the sticks provided as nesting material if some of the original lining was removed.

In the first test 20 white sticks and 20 black sticks were placed systematically around each nest within a 20-cm radius. A black and a white stick were always placed together, thus forming 20 pairs of sticks. The radius of 20 cm was chosen so that if there were any selection of material it would have a good chance of being incorporated in the nest lining and thus be recorded.

For the second test 20 white and 20 black sticks were placed in a small container. After shaking the container, the sticks were poured into the nest. This method was preferred over systematic placement because of the quantity of sticks and four large eggs within a limited space.

To make the black sticks more contrasty, white marble dust was spread over the entire nest within a 20-cm radius after the second test. In the third test 20 white and 20 black sticks were placed systematically around the nest as in test 1, but this time they were on a white substrate.

Each testing period was concluded at the end of 3 days. Periodic recordings were taken during the entire testing period. In all three tests the measure of selectivity was the proportion of black and white sticks in the nest at the end of the test period.

The results of the tests are presented in Table 1. Note that tests 1 and 2 were run on all 20 nests, but it was not always possible to conduct the third test. The eggs of nest 12 and 17 hatched before test 3 could be

TABLE 1

RESULTS OF BLACK AND WHITE STICK SELECTION[1]

Nest site number	Substrate type	Test 1		Test 2		Test 3	
		W	B	W	B	W	B
1	1	19	1	15	1	14	2
2	1	2	0	12	6	1	1
3	1	5	0	15	9	13	4
4	1	9	6	13	9	14	10
5	1	10	0	17	9	9	0
6	2	11	0	17	9	5	0
7	2	9	0	20	10	6	1
8	2	17	10	19	12	20	5
9	2	7	0	7	1	2	1
10	2	0	0	14	17	1	0
11	2	11	1	10	8	10	6
12	2	11	0	13	9		
13	2	16	2	20	18	20	18
14	2	16	2	19	18	13	3
15	3	13	1	20	18	7	3
16	3	17	5	18	13		
17	3	8	0	16	13		
18	4	7	1	20	20	1	3
19	4	19	12	18	17	18	12
20	4	5	4	7	8		

[1] Test 1, sticks placed around the nest; test 2, sticks in the nest; test 3, sticks placed around the nest on a white substrate. W = white, B = black. Substrate type 1, white gravel; 2, fields with little or no vegetation; 3, fields with some vegetation; 4, fields heavily covered with vegetation.

run; nest 16 was destroyed by predators the day after the marble dust was added; nest 20 was deserted soon after test 2.

The sign test was used to analyze the data. The null hypothesis for the sign test states that there is no difference in the two populations ($P = 0.05$). No assumptions need be made with this test (i.e. population probability distribution). Assigning a plus in each case when white sticks outnumber black ones in the nest and a minus when black sticks either outnumber or equal white sticks, the results can then be tabulated. Test 1 has 19 pluses and 1 minus, which indicates a level of significance of $P < 0.001$. In test 2 17 pluses and 3 minuses shows a significance of $P < 0.01$. Test 3 had 16 observations with only 2 minuses, indicating a $P < 0.01$ level of significance. All three tests demonstrated that white is being selected and the null hypothesis is rejected. The results of test 2 indicates that more black sticks were removed from the nest than white ones.

As noted earlier, substrates vary considerably in Killdeer nest sites. Despite the small numbers of observations of some of the substrate types, a test was run to detect any variation within these groups. The data of each site were subjectively placed into one of the four substrate types (Table 1). The Kruskal-Wallis one-way analysis of variance test (Mendenhall et al. 1971) was applied using the proportions of white sticks in the nest for each substrate type. In all three cases the null hypothesis failed to be rejected.

Correlation of substrates with the number of white sticks used by Killdeer can be tested in another way. Because of their similarity except for white substrate, the results of tests 1 and 3 were compared using both the paired T-test and the Wilcoxon matched-pairs sign test (Haber and Runyon 1969). The T value is 3.702 with 13 degrees of freedom. In both tests the level of significance is less than 0.01, showing a strong correlation. Of the 14 sites tested 12 showed a higher proportion of white sticks used in test 1 than in test 3. Ignoring any behavioral function, one may explain this correlation by a decreased desire in nest-building towards the waning of incubation.

The possibility that white sticks are more easily seen than black ones could result in higher selectivity, but this is rejected because nests 1–5 were predominantly on white gravel where black sticks were more conspicuous. The black sticks on the white marble dust in test 3 also were more visible. To test conclusively that the white sticks were the ones desired, all the sticks were placed in the nest in test 2. The results indicate that the birds took out more of the black sticks.

Researchers have made many observations of Killdeer nests containing large amounts of white material. Allen (1932) reported small white chips lining a Killdeer's nest while Butler (1937) saw one surrounded by old bones. Stockard (1905) and Miller (1949) described Killdeer nests consisting of bits of shells, small pebbles, weeds, and sticks. According to Tyler (1913) a typical nest in the Fresno district of California contained a handful of white pebbles about the size of peas. Bates (1916) and Pickwell (1925, 1930) observed that Killdeer nest material included many light-colored objects while Risser (1931) noted small chips of limestone and shotgun wads in the nest. Pickwell (1925), Allen (1932), Stoner (1937), Abbott (1944), and Wass (1974) all found Killdeer nests on the tops of flat buildings with roofs of white crushed rock. Jackson (1924) actually attracted Killdeer to nest in a meadow on his farm by spreading oyster shells on two 15-foot-diameter plots. Of eight nests found on an athletic field, five were placed on the white boundary lines composed of crushed limestone (Nickell 1943). Killdeer have also been known to nest on white lines of parking lots (W. D. Graul pers. comm.). I have found such items in Killdeer nests as white quartz, cigarette butts, white plaster chips, paper straws, and silver gum wrappers.

Stimulated by these findings in the literature, Bunni (1959) compared the material in Killdeer nests with the material outside nests. He concluded that they do select white, but the experiment was not performed under controlled conditions.

The usage of white material also occurs in other members of the subfamily Charadriinae. The use of bits of shells for nest lining has been reported in *Charadrius melodus* (Wilcox 1939, 1959), *C. rubricollus* (Littlejohns 1932), *C. wilsonia, C. semipalmatus, C. hiaticula*, and *C. alexandrinus* (Bent 1927).

Two possible functions of the selection of white sticks can be immediately identified. The first is temperature regulation. White, being more reflective, could conceivably keep the nest cooler. The problem of overheating is a constant threat to open ground-nesters. I have repeatedly seen Killdeer shading their eggs as well as wetting their feathers to keep the eggs cool. The birds themselves must be on the nest most of the time while hyperventilating during the heat of the day.

The other possible function is cryptic coloration. Concealment is an important factor for the survival of many ground-nesting birds. Disruptive coloration, a form of concealment, already appears to be important in the subfamily Charadriinae. As Graul (1973) pointed out, most head and breast patterns disrupt the body outlines and therefore conceal the rather vulnerable bird.

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Gray-rumped Tattlers catching fish.—On 23 April 1974 I watched two Gray-rumped Tattlers (*Heteroscelus brevipes*) for 15 min catching fish off Stonecutters' Island in Hong Kong Harbour. The birds were standing on a flattish rock about 15 m from the shore, which was periodically washed over by the sea. The birds occasionally picked up the fish (about 4 cm long) when they were left stranded on the rock, but more often they ran into the sea, up to their bellies, to catch fish. They always ran back out of the water before swallowing their prey. Although a Common Sandpiper (*Actitis hypoleucos*) was also present on the same rock for 5 min, it never attempted to take fish.

At the time the observations were made shoals of small fish, often containing many thousands of individuals were numerous around Hong Kong, and it was not uncommon to find many individuals stranded along the beaches. A number of Gray-rumped Tattlers were seen in autumn 1974 and spring and autumn 1975, but no large fish shoals were present, and this method of feeding was not seen again. Bent (1929, Life histories of North American shorebirds, U.S. Natl. Mus. Bull. 146: 41–49), Dement'ev and Gladkov (1969, Birds of the Soviet Union, vol. 3, pp. 268–273), and Witherby et al. (1940, The handbook of British birds, vol. 4, pp. 343–346) do not mention fish in the diet of the Gray-rumped Tattler.—David Melville, *705B, 19 Ho Man Tin Hill Road, Kowloon, Hong Kong.* Accepted 29 Jun. 1976.