of the domestic fowl, except that the Islets of Langerhans (in the pancreas) are separated from the remainder of the pancreas by connective tissue (fig. H).

EXPLANATION OF PLATE 9

**Figure A** Typical digestive system of English Sparrow (intestines have been loosened from mesenteries)

1 Oesophagus
2 Crop
3 Proventriculus
4 Ventriculus
5 Duodenum
6–8 Jejunum and ileum
9 Rectum
10 Caeca
11 Liver
12 Gall bladder
13 Pancreas

B Section of ventriculus 110 ×
1 Tunica propria
2 Submucosa
3 Muscles of mucosa

C Section of duodenum 110 ×
1 Villi showing goblet cells
2 Submucosa with Glands of Lieberkühn

D Villi of rectum showing goblet cells, lacteals, and blood vessels 440 ×
E Submucosa of rectum with Glands of Lieberkühn 440 ×
F Section of rectum showing grouping of villi 110 ×
G Irregular villa 110 ×
H Section of pancreas with blood vessel and Islet of Langerhans 440 ×

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## THE BROKEN-WING BEHAVIOR OF THE KILLDEER

BY C. DOUGLAS DEANE

*Plates 10, 11*

THE most interesting behavior of the Killdeer (*Oxyechus vociferus*) is its polished performance of the broken-wing action—a device useful to many ground-nesting birds in luring enemies from the nesting area.

The display of the broken-wing trick is, in the opinion of many observers, a reflex action that automatically functions when an enemy enters the breeding territory. It is not dependent upon the presence or absence of eggs or young. In the case of the Killdeer, I cannot help thinking that it is too polished a performance to be merely a reflex action. There must be a considerable amount of training and intelligence combined in this trick, as the bird has evolved procedures that

vary with the different types of enemies. The production of a different display best suited to the characteristics of the approaching enemy is surely evidence of something more than mere instinct. Bent (Bull. U. S. Nat. Mus., 146: 208, 1929) quotes an observation describing the reaction of a nesting Killdeer to a man on horseback, in which the Killdeer showed great intelligence in switching from the display used for the ungulates to the broken-wing behavior used for the enemy, man.

The brilliant cinnamon coloring of the lower back and tail is displayed as a threat color, like that of the red breast of the British Robin (*Erithacus rubecula melophilus*). I saw it used toward another male, that had entered the territory, when the resident male ran toward the newcomer with wings open (Plate 10, middle figure) and, when about six feet away, suddenly turned about so that the brilliant tail coloring flashed into view. It is used also as a means of attraction when both sexes posture with wings half open, exposing the yellow hues, but in this case the tail is arched over the back and not depressed as in the threat display.

Would not the Killdeer be better off, when danger threatens, by: (A) leaving the protectively-colored eggs and disappearing as silently as possible, as does the European Curlew (*Numenius a. arquatus*), and remain away while the enemy is in the territory? The bird must realize that its eggs are colored protectively by the way it furtively abandons the nest. Or (B) sitting perfectly still on the eggs, relying on its ruptive coloration to escape observation as does the American Woodcock (*Philohela minor*)? If the eggs were not protectively colored as in the Anatidae, there would be some design in the Killdeer's method of throwing itself into the limelight.

The most important time, I think, for the proper use of the broken-wing action is after the eggs have hatched and the young are scattered in the undergrowth. A Spotted Sandpiper (*Actitis macularia*) had its nest thirty feet from that of a Killdeer and, although I entered its territory many times, never did I see any display aimed at attracting my attention until the eggs had hatched. Then one of the adult birds ran along the water's edge with both wings half-closed and beating wildly. Whether by accident or design the Killdeer has, by its wild alarm cries and extensive posturing, removed the ever-present danger from the eggs to itself.

The duration of the broken-wing reflex lasts from the time the Killdeer assumes a recognized breeding territory until the young are seven to ten days old and the potency of sex-control has diminished.

The procedure of the broken-wing action varies with the approach

(Upper figure), KILLDEER IN THREATENING ATTITUDE TOWARD ANOTHER KILLDEER. (Middle figure), ATTITUDE TOWARD AN ENEMY ENTERING THE TERRITORY. (Lower figure), BROKEN-WING BEHAVIOR. *(Photographs copyrighted by the author.)*

of the different enemies. With man as an enemy, the bird displays when twenty to thirty feet away, with the distance appearing to decrease as hatching time approaches. When the young are hatched, the brooding bird performs about ten feet away. With canine enemies, the birds trail along about six feet in front. With non-predatory enemies like sheep and cattle, the bird does not leave its nest at all but waits until the animal is three or four feet distant before frightening it away.

PHASE I.—This is applied to predatory animals such as man, fox, dog, etc. When I opened the gate of a field in which Killdeers were breeding, the brooding bird ran off the nest almost immediately, although I was still at least fifty yards away. Crouching, running silently and fast, the bird made for the opposite corner of the field. If I stopped or kept away from the nest no action was taken beyond agitated alarm calls and constant flight around the territory by both birds. When I approached the nest, one of the birds, presumably the one that was brooding, would alight about twenty feet away and run toward me, crouching with wings half open but the primaries not extended, uttering a piercing alarm call (Plate 10, upper figure).

This procedure has an alternative that I witnessed on numerous occasions, especially if I moved too fast towards the nest; the bird ran toward me with wings held high over the body (Plate 10, middle figure) and the tail spread but not depressed. If I stopped or moved away, the display ceased but the bird continued its wild alarm calls.

PHASE II.—When I moved toward the nest, the Killdeer suddenly turned around so that its tail was toward me and the yellow threat-color was shown. The bird now exhibited the true broken-wing behavior. Calling all the while, it crouched on the full length of the tarso-metatarsus with the wings drooping, exposing the brilliant ochraceous color of the rump and tail. The tail was depressed with the feathers cutting against the soil, one wing was beating violently on the ground and the other wing was half open, twisted against the back, and waved excitedly in the air. The bird eyed me for a sign that I was interested; I was and so followed it. The Killdeer immediately rose and ran rapidly for some six feet with its wings hanging loosely, the tail still spread, and the bird leaning to one side. It crouched again and performed the same trick, sometimes with variations, beating both wings on the ground or waving them above the back (Plate 10, lower figure).

The displaying bird likes to be screened by a plant-stalk or a stone, no matter how small. The procedure is normally repeated until the

enemy has been lured away from the eggs. Usually only one bird performs at a time but, when hatching time approaches, both birds may perform together; in fact when I was watching the pair displaying, one bird—the male—suddenly stopped, ran over to the eggs, and continued to brood while the female continued the broken-wing performance.

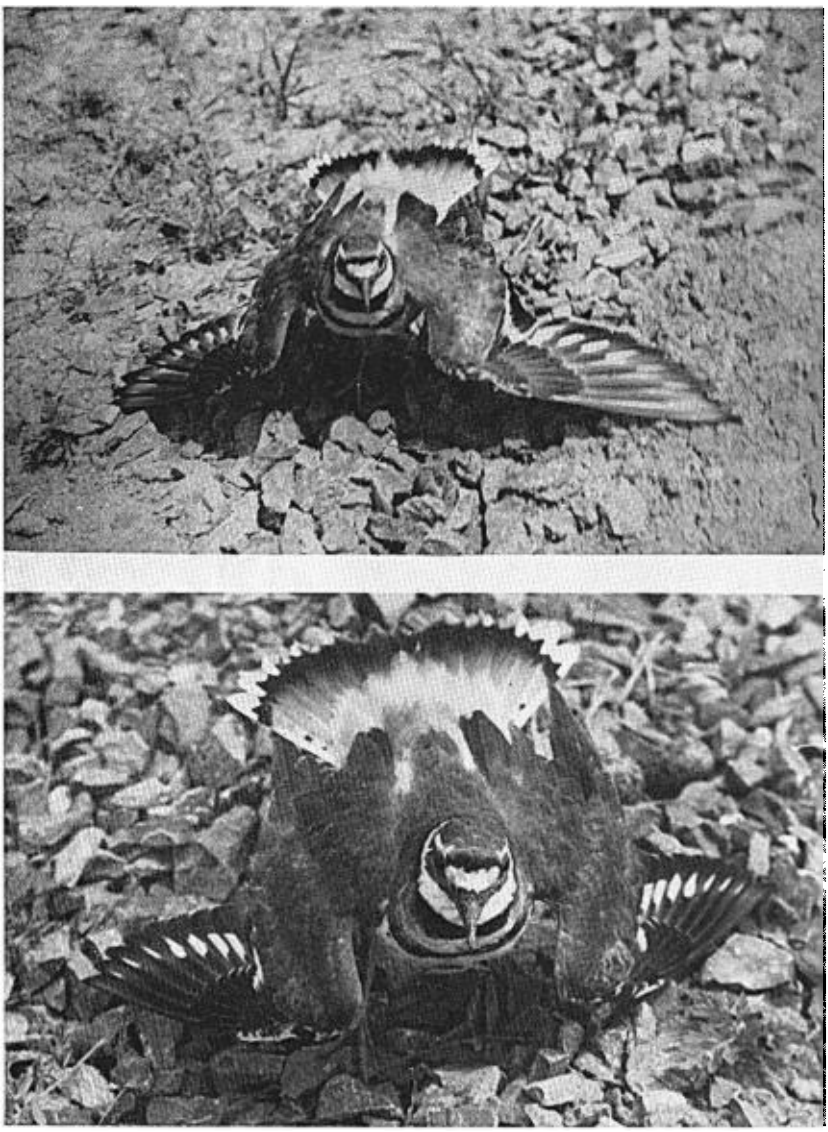
PHASE III.—I was fortunate in seeing this type of display since it varies only slightly from the posture adopted for frightening ungulates (Plate 11, lower figure). It occurred as I approached the nest on my customary inspection to see if the eggs had hatched. The brooding bird, instead of slipping off the nest and creeping away, as was the usual practice, stood in front of the nest with the wings spread on the ground in an arc and calling excitedly (Plate 11, upper figure). I can explain this peculiarity only by the fact that an egg had hatched in the nest and caused the wrong type of display.

PHASE IV.—The procedure for the protection of the eggs from such intruders as cattle and horses varies according to circumstances. I once witnessed the leisurely approach of a cow towards the nest. When the animal was about ten feet from the nest, the brooding bird became excited and stood in front of the eggs, calling. It fluffed its feathers out and, with the trailing wings occasionally beating on the ground or waved wildly in the air, it ran toward the cow. Then it suddenly flew up and hit the beast on the muzzle, dropping to the ground before flying sharply in front of the animal's head, uttering all the time a peculiar wheezing cry. The frightened but uninterested mammal shied to one side and continued its leisurely progress across the field, missing the nest with its hoofs by almost six feet (Plate 11, lower figure).

On another occasion, I arrived to find my blind smashed and the imprint of a cow's hoof in the center of the Killdeer's nest. The cow, no doubt, had been attracted by the unusual object which may have had something to do with the failure of the Killdeer to save her eggs.

PHASE V.—Correlated with the broken-wing action is a subsidiary display of dummy nest-brooding. It takes place during phases I and II and is another example of the high degree of protection that the Killdeer gives its eggs. The decoying bird, during one of her short runs in the midst of the display, will suddenly squat down behind a plant stalk or in a hollow and shuffle about as if settling on eggs. I have no data on whether this procedure is adopted for enemies other than man.

I am of the opinion that when the eggs hatch and the young are



(Upper figure), ATTITUDE OF A KILLDEER TOWARD A MAN APPROACHING THE NEST. (Lower figure), STANDING IN FRONT OF EGGS AT THE APPROACH OF AN UNGULATE. (*Photographs copyrighted by the author.*)

seven to ten days old, the breeding territory becomes common ground and other Killdeers are not molested. In fact, a form of mutual aid exists and the young seem to be pooled. On the approach of danger, the broken-wing action is discarded for vigorous flight and wild alarm calls around the intruder. I once found six nestlings being protected by four adults, which may or may not be the usual practice.

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## SOUTHEASTERN LIMITS OF THE SPOTTED SANDPIPER'S BREEDING RANGE

BY HENRY M. STEVENSON, JR.

ACCORDING to the A. O. U. Check-List (1931), the southeastern breeding limits of the Spotted Sandpiper (*Actitis macularia*) are "southern Louisiana, central Alabama, and northern South Carolina." The records on which this statement is based are hazy, however, and some apparently are quite undependable. Furthermore, my own experience in the South (1929–1941) leads me to believe that the species does not breed regularly (if at all) anywhere south of central and eastern Tennessee and western North Carolina.

Inclusion of "central Alabama" in the statement of range is based on Howell's 'Birds of Alabama' (1928). Among the definite dates listed in this work, those which most nearly approach the breeding season are May 25 (at Leighton) and June 1 (on Petit Bois Island). These dates are not abnormally late for the spring migration. I have found late individuals at Birmingham on May 25, 1935; at Florence, May 25, 1941; and at Tuscaloosa, May 28, 1938.

Without citing definite dates, Howell (*op. cit.*) also states that the Spotted Sandpiper has been observed "in the breeding season" in Autauga County, on the Tensaw River (near Stockton), at Stevenson, Seale, and Bayou Labatre, and on Petit Bois Island. By a study of the dates of occurrence of other species recorded by Howell at the same localities, it is possible to determine within a few days the dates during which he visited these localities. The record at Stevenson was made on or about July 15, at Seale about May 22, at Bayou Labatre about May 20, and on the Tensaw River about May 27. The date of the Petit Bois record is mentioned above.

The listing of the Spotted Sandpiper in Autauga County in the breeding season probably rests on L. S. Golsan's manuscript notes, where it is called a "summer resident." Careful reading of these