

Slightly more than one-third (35%) of the eggs in three-egg clutches had a crown (Table 2), which was progressively more common from the first through the third egg, and showed a significant relationship to the egg's position in the hatching sequence ( $P < 0.005$ ). When a definite crown occurred this crown occurred 6.6 times more frequently on the third egg than on the first and 3.8 times more frequently on the third egg than on the second. A definite crown occurred 1.7 times more frequently on the second egg than on the first. This agreed with Preston's (ibid.) findings with the Laughing Gull and Common Tern.

In two-egg clutches a crown (faint or definite) occurred 2.7 times more frequently on the second egg than on the first (Table 2), but a Chi-square test showed no significant relationship between the presence of a crown and the hatching sequence in two-egg clutches. Preston (ibid.) also found no difference between the first and second eggs of the Common Tern.

Over one-quarter (28%) of the three-egg clutches contained one differently colored egg with two eggs of the same color. The one egg that differed in color was the third to hatch 79% of the time and the first to hatch 21% of the time. The second egg was never found to be the differently colored egg of a clutch. Assuming there was an equal probability that each position in the hatching sequence might be held by the differently colored egg, a Chi-square analysis was made ( $P < 0.005$ ), showing that when a three-egg clutch had two eggs of one color and one egg of another color, the differently colored egg was most likely to be the third egg.—MICHAEL L. CHAMBERLIN, *Interlochen Arts Academy, Interlochen, Michigan 49643*. Accepted 14 Nov. 75.

**Sizes of snails eaten by Snail Kites and Limpkins in a Costa Rican marsh.**—Both the Limpkin (*Aramus guarauna*) and the Snail Kite (*Rostrhamus sociabilis*) feed on freshwater molluscs. The Limpkin may prey upon a variety of molluscs (Snyder and Snyder 1969, Living Bird 8: 177), but the Snail Kite is known to feed almost exclusively on prosobranch snails of the genus *Pomacea* (Sykes and Kale 1974, Auk 91: 818). This paper reports a difference in the distributions of shell sizes of *Pomacea* consumed by kites and Limpkins at a marsh where both bird species appear to feed exclusively on *Pomacea*.

The Limpkin and the kite employ different strategies in capturing snails and in extracting them from their shells. The Limpkin wades about in the shallows, probing the bottom until its bill contacts a snail, which it then carries to a suitable elevated, flat spot on the marsh, hammers out the operculum with a sharp blow of the bill, and extracts the meat. The bill makes a characteristic notch in the columellar edge of the operculum and frequently makes a hole in the dorsal side of the shell opposite the point of entry. Other foraging techniques have been reported for the Limpkin (Snyder and Snyder op. cit.), but were not observed at the study site. The kite, on the other hand, searches visually while flying over open water. It can forage over water that is too deep for the Limpkin to wade in. The kite takes snails that are at or near the surface, carries its prey to a perch and then extracts the meat with a quick stroke of the beak. Generally the kite leaves no mark on the discarded shell or operculum (Snyder and Snyder op. cit.).

Empty snail shells accumulate at the habitual feeding sites of individual kites and Limpkins. One can determine which predator species was responsible for the formation of a particular pile of shells by the presence or absence of perforations in some of the shells.

Fieldwork was done in January 1975 at the Organization for Tropical Studies field station at Palo Verde in Guanacaste, Costa Rica. The study was conducted on the large freshwater marsh south of the field station. The marsh consisted of extensive patches of rushes, grasses, water hyacinth, or open water. *Parkinsonia* trees were scattered throughout the shallower wetlands. *Pomacea* of unknown species were abundant, as evidenced by their empty shells, which formed an integral part of the sediments. The ubiquity of piles of snail shells suggested that Limpkins and kites were the major predators of *Pomacea*. Most of these piles seemed to have been made by Limpkins.

I collected samples of shells from discrete piles. As the kites I saw invariably perched in *Parkinsonia* when feeding, only piles found under these trees and having few or no perforated shells were assumed to be of kite origin. Piles located under *Parkinsonia* trees and having a noticeable frequency of perforated shells were rejected to avoid samples of mixed origin. Piles made by Limpkins were sampled from various parts of the marsh. A 2- to 4-liter sample of shells was taken from the center of each pile used. I sampled 7 piles accumulated by kites and 17 attributed to Limpkins. The greatest length of each shell was measured in millimeters using a rectangular frame and rule (see Fig. 1, inset). In all I measured 1373 shells (320 kite, 1053 Limpkin).

The mean length for all Limpkin shells combined is 34.77 mm, with a standard deviation of 5.45 mm. Shells from kite piles averaged 43.18 mm, with a standard deviation of 6.03 mm. The difference between means, using all piles combined for the same bird species, is significant ( $P < 0.01$ ) by the approximate

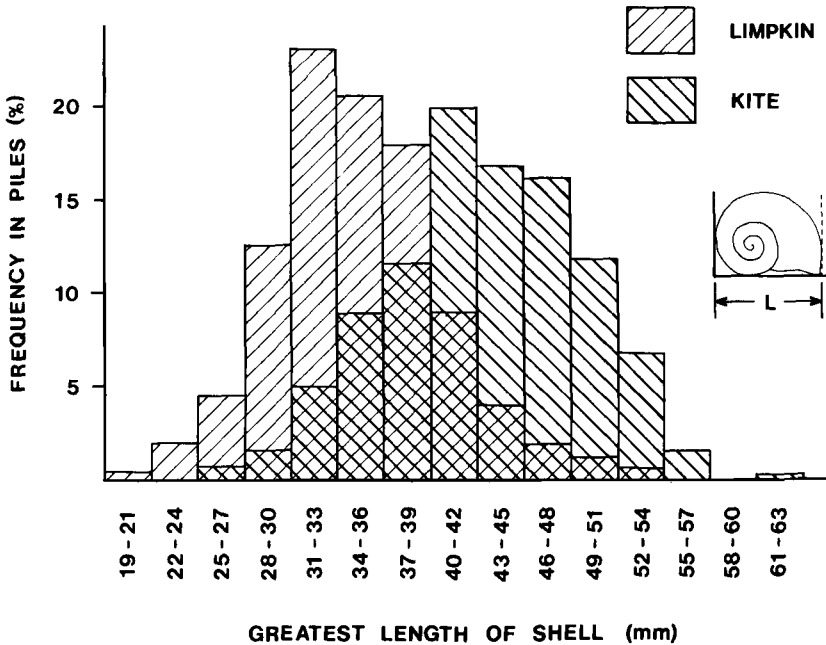


Fig. 1. Frequency distributions of greatest length of shells from piles accumulated by Limpkins and Snail Kites.

*t*-test with Welch's estimated degrees of freedom (Kirk 1968, Experimental design: Procedures for the biological sciences, Belmont, California, Wadworth, pp. 106-107). Shell lengths ranged from 22 to 55 mm for Limpkin piles and 26 to 61 mm for kite piles. Fig. 1 shows shell size distributions, using 3-mm intervals for clarity.

The observed difference in the sizes of prey taken by these two birds may reflect evolutionary adjustments in their feeding mechanisms, either as carry-overs from their phyletic histories or as character displacement caused by competition with each other. The larger size of prey taken by kites may be a result of larger snails being easier for them to see. It is also possible that the kite's talons are better suited to larger snails, or that large snails are difficult for Limpkins to open, but the extremes of prey sizes taken by either species are quite similar. Both shell size distributions are distinctly skewed, as indicated by Fisher's  $g_1$  statistic (Bliss 1967, Statistics in biology, vol. 1, New York, McGraw-Hill, pp. 144-145). The distribution for Limpkin piles is positively skewed, with  $g_1 = 0.478$ , whereas, the distribution for kite piles is negatively skewed, with  $g_1 = -0.131$ . The observed deviations are significantly different from normality at levels of  $P < 0.001$  for Limpkin piles and  $P < 0.1$  for kite piles. The overlapping skewed tails of these distributions suggest that either species may take practically any size of snail available, but on the average they take prey that are distinctly smaller or larger than those taken by the other snail predator.

Whether or not kites and Limpkins are in close competition for *Pomacea* at Palo Verde is a difficult question to test. Data are needed on size distributions of available snails and how these distributions vary spatially and temporally. The difference in sizes of prey may also reflect age-specific variation in the use by *Pomacea* of different habitats. If older, larger snails were more prevalent in deep water, they would be more available to kites than to Limpkins. A study of the distribution by size of live *Pomacea* in the marsh could illuminate this question but was not undertaken in the present study for lack of time and because of the difficulty of locating submerged live snails in the turbid marsh. Moreover, the amount of open water available to kites foraging on the marsh varies greatly between the dry season (December through April), when piles were sampled, and the wet season (May through November). How these changes affect the area of the marsh available to the Limpkins could not be evaluated during this brief study. The two species did not establish exclusive foraging territories: kites and Limpkins were often seen foraging at the same time in the shallower channels of the marsh. It should be recalled that although the kite seems to be dependent on *Pomacea*, the Limpkin may switch to other prey when the snails are scarce (see Snyder and Snyder op. cit.). Given that the marsh contains only one species of *Pomacea*, and given the high degree of

specialization by the kite for feeding on *Pomacea*, during times of resource scarcity the Limpkin, by taking the smaller snails, may greatly reduce the future availability of the larger snails that the kite selects.

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**Abnormal nest building in the Eastern Phoebe.**—Several instances of birds abnormally building multiple nests have been reported. Welty (1975) cited instances of the American Robin (*Turdus migratorius*) and the European Blackbird (*Turdus merula*) beginning numerous nests on horizontally hung ladders, girder spaces between roof rafters, stacks of pipes, and pigeon-holes. Herrick (1935) told of an American Robin that began five nests on steps of a fire escape, completed two, and divided the clutch between them. Ashmole (1968) similarly reported an Eastern Phoebe (*Sayornis phoebe*) that built two complete nests and divided the clutch between them; two young were ultimately fledged from one of these nests. The usual explanation for this aberrant behavior revolves around the repetition in man-made structures and the inability of birds to identify the proper site. The observations for this paper were made from 1970 to 1972 on Crane Naval Ammunition Depot, Indiana, in conjunction with a study of Eastern Phoebe and Barn Swallow (*Hirundo rustica*) breeding ecology.

On 21 April 1970 I found Eastern Phoebe nesting material (i.e. fresh moss and mud) forming a continuous thin mat for some 2 m along the west side of a central I-beam under bridge 25, a small wood and steel I-beam bridge that extended north-south over an east-flowing stream (Fig. 1). The date of the beginning of the mat's construction is unknown, but many first nests were begun before 10 April that year. On 27 April the depth of the mat had been substantially increased, but the length was only slightly greater. By 7 May, a typical nest cup had appeared at the south end of the mat. No further construction was noted. At this time the nest mat was 2.2 m long and 2.50–3.75 cm thick for 1.0 m, and 1.25–2.50 cm thick for the remainder of the length. The first egg of a five-egg clutch was laid on 8 May, and five young fledged successfully on 13 June. All aspects of the nesting cycle after nest building appeared normal. This nest was destroyed during the winter, and a normal nest was built and young fledged during the 1971 nesting season. A single visit to the bridge on 1 June 1972 revealed an abnormal nest very similar to the 1970 nest although of smaller dimensions. This nest, which contained five eggs, was on a west-facing I-beam, and the cup was at the north end of the mat.

A second type of aberrant nest was found on 2 June 1972 under bridge 49, also a wood and I-beam bridge, 8 km from the former. This nest, also with greater than normal dimensions, was uniquely composed of 5 separate cups, 2 cups descending as steps in each direction from the complete central cup



Fig. 1. Abnormal nest with extensive base built in 1970 at Crane Naval Ammunition Depot, Indiana.