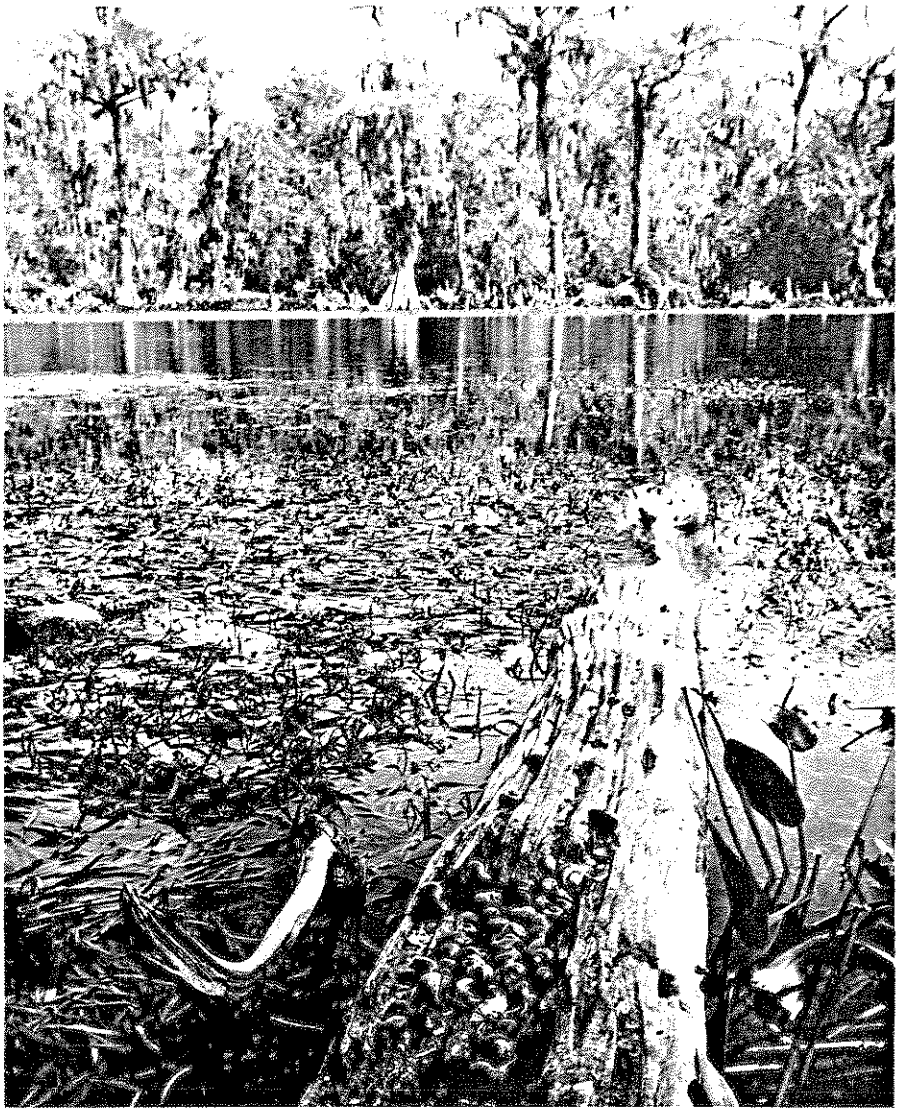

Figure 7. Feeding log of Limpkins at Wakulla Springs. When there is a shortage of firm bases on which to rest the mussels or snails for extraction, the birds often use the same one over and over again, leaving behind heaps of empty shells.

Extracting Mussels from Shells

After bringing a mussel to a substrate, the Limpkin generally rains heavy blows on it with its bill and, between blows, repositions the mussel with its bill. Since the Limpkin often extracts prey in shallow water or in thick vegetation, it was usually difficult for us to see how the bird oriented a mussel before delivering a blow. On three occasions, out of the 21 times we watched Limpkins open mussels with blows, the initial orientation of the mussel was clear: The Limpkin placed the shell hinge down, ventral edge uppermost (Figure 8), and the long axis of the shell aimed toward its feet. In one case it was clearly the anterior end of the shell that faced the Limpkin. However, damage to shells indicates that the birds do not always orient mussels in this way.

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At Lake Okeechobee and 12 miles east of Belle Glade along Route 441, we collected the shells in Figure 9 immediately after seeing Limpkins open them with blows. Figure 10 shows mussel shells collected along a roadside canal south of Clewiston in Devils Gardens. We watched Limpkins open three of these with blows and then collected all the shells on the shore where the birds had been working. Limpkins had probably opened them all. On 7 March 1968, at Wakulla Springs, we took 22 mussel shells from feeding stations of Limpkins, knowing that Limpkins had opened at least six, and possibly all, with blows.

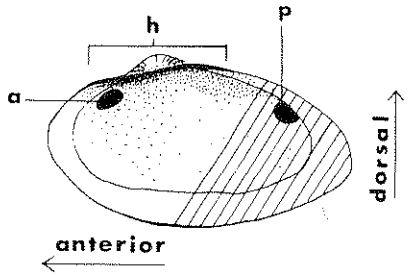

Figure 8. Typical valve of a freshwater mussel: Shaded area, the region most damaged by Limpkins; a, scar of anterior adductor muscle; p, scar of posterior adductor muscle; h, hinge of valve.

The damage to the shell is usually concentrated at the posterior ventral portion (Figure 8), the fastest growing and also the thinnest and weakest area (Norton-Griffiths, 1967). Of the 44 shells, 31 were damaged in this area alone, 11 were damaged in this area and elsewhere, and two were damaged elsewhere only. Ventral damage predominated: 23 shells were damaged in ventral areas only; 18 in ventral and dorsal areas; and three in dorsal areas alone. In 41 of the 44 shells the edges of the valves were damaged; the three others were damaged so badly we could not be certain that blows had struck the edges. Nine shells also had small holes, often paired, in the sides of the valves (Figure 11). Twenty of the 44 showed approximately equal damage to the two valves; 12 showed more damage to the left valve; eleven, more to the right; and one, since it lacked a valve, was unclassifiable. In summary, the damage indicates that mussel shells are usually placed hinge downward for blows which are usually directed at the ventral posterior end where the valves meet.

When damage is sufficient, the Limpkin jams its slender lower bill between the valves and, with its upper bill resting most commonly in the hinge region of the shell (Figure 12), cuts both muscles which hold the valves shut. When the muscles are severed, the valves spring open and the Limpkin frees the animal with a variety of manipulations, working mostly with the upper bill outside the shell and the lower bill between the valves. When the mussel is entirely free, the bird picks it up in the tip of the bill, tosses it into the air, catches it farther up in the bill, and swallows it. Sometimes, especially with large mussels, the Limpkin may eat the animal in several chunks (Figure 13). Often the bird shakes the meat vigorously before eating, sending into the air small bits of tissue which, in many cases, it never eats. The discarded valves usually show stumps of the adductor muscles and, occasionally, pieces of mantle still attached.

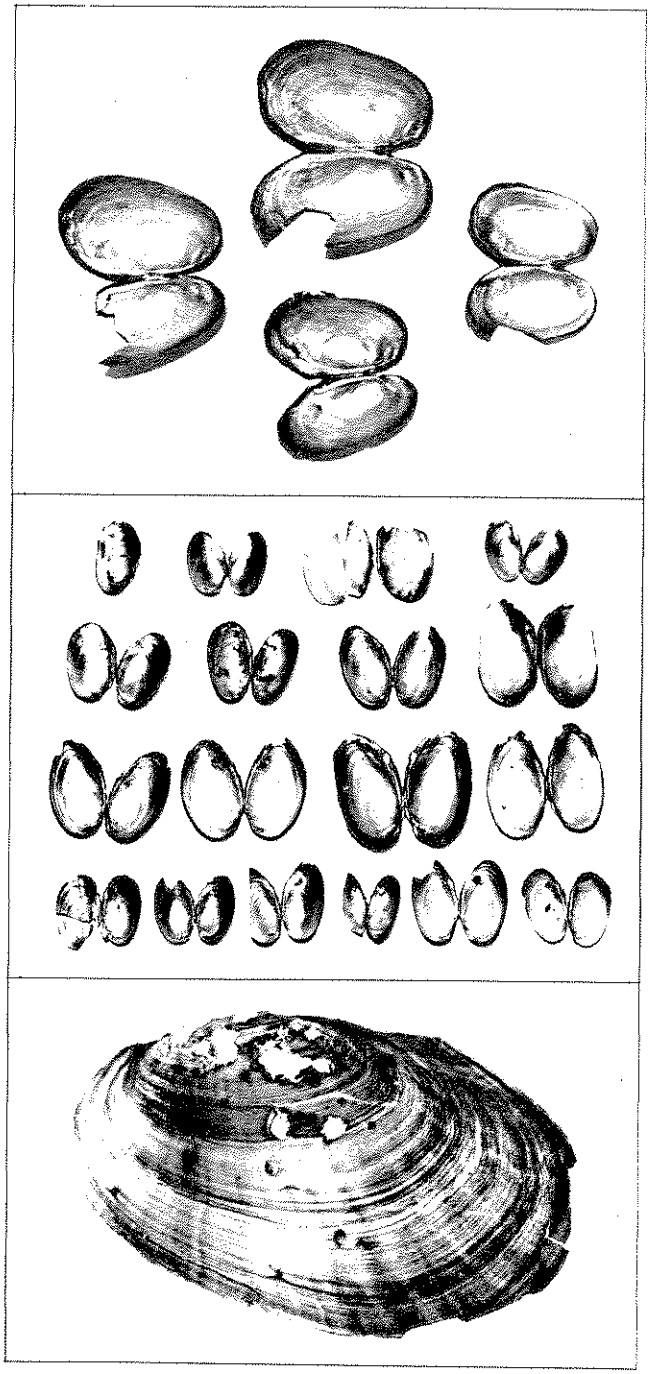

Figure 9 (*top*). Mussel shells opened by Limpkins and collected by the authors almost immediately after the birds had eaten the contents. Note the consistent damage in the posterior ventral area, the thinnest portion. For this photograph and for all other photographs of mussel shells in this paper, the authors spread the shells flat. Limpkins do not normally open mussels this far.

Figure 10 (*middle*). Mussel shells collected along a roadside canal at Devils Garden where Limpkins were feeding. The birds opened at least three and probably all of these mussels.

Figure 11 (*bottom*). A mussel shell with paired holes. There were nine shells at Devils Garden damaged in this way, presumably, by Limpkins.

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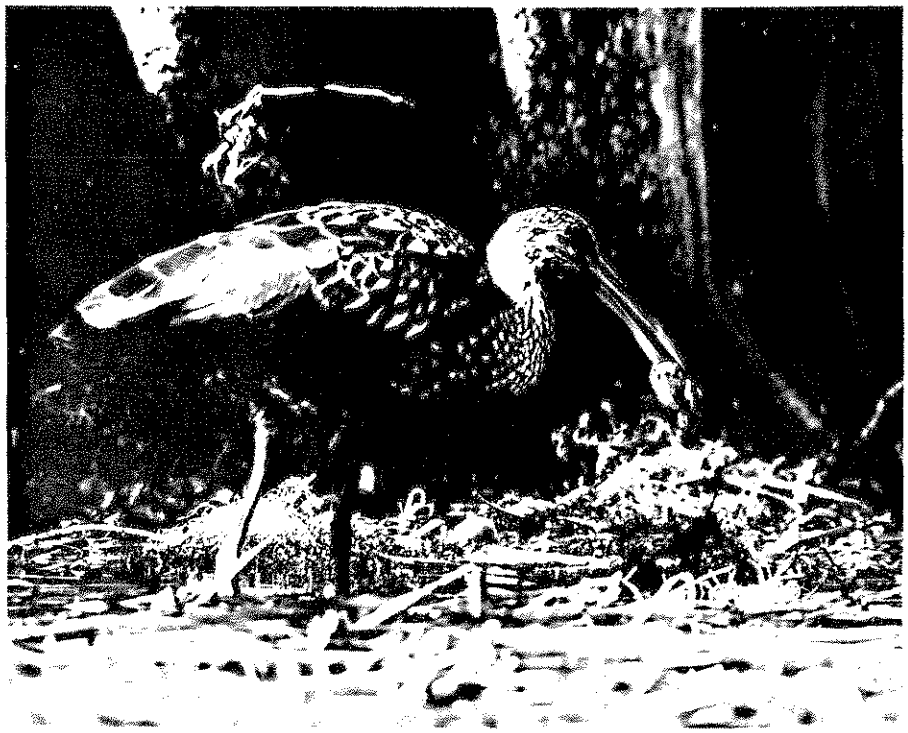

Figure 12. Limpkin cutting the adductor muscles of a mussel. After the bird has damaged the shell with blows, it forces its lower bill between the valves and slices the two muscles that hold them together.

The number of blows required to gain entry to a mussel varied, in our observations, from zero to 29. In most localities Limpkins always used blows to open mussels. At Wakulla Springs, in five instances out of 17, they opened mussels without blows. Apparently the birds managed to wedge their lower bills between the valves in some other way. In one case the Limpkin already had its lower bill between the valves when it came up with the mussel. Since mussels, undisturbed in water, normally have the valves partially open at the posterior end, which faces upward, the Limpkin may have been quick enough to insert its bill before the mussel closed. The other four cases may have been similar. We were not close enough to see.

On 17, 18, 19, and 24 April 1968, at Saddle Creek Park near Lakeland, we saw a pair of Limpkins extract several dozen mussels (*Anodonta cooperiana*) without blows. Since it was clear in most cases that the birds were not getting their bills between the valves in the capturing process, we suspected there might be something peculiar about the mussels. We caught some *A. cowperiana*, by far the most common species at Saddle Creek, and found that almost all had difficulty in closing the valves tightly together even after being handled out of water for a minute or two. Apparently the Limpkins had no trouble wedging their lower bills into the space left between the valves (Figure 14). Two other less common species of mussels at Saddle Creek Park, *Villosa vibex* and *Elliptio strigosus*, did close the valves tightly, but we never saw Limpkins feeding on them at this locality.

Figure 13 (*above*). Limpkin grasping a small chunk of a large mussel, *Anodonta cowperiana*. Sometimes when the mussel is free of its shell, the bird swallows it whole; in the case of a large mussel, the Limpkin usually eats it in chunks.

Figure 14 (*below*). Opening a mussel without blows. The bird wedged its lower bill between the valves of *Anodonta cowperiana*, a species that, in this particular locality, opened slightly after being out of the water a short time.

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Hudson's description of Limpkins, in Argentina, opening mussels are only speculations and do not correspond closely with our observations. He wrote (1920:173):

> Every shell has an angular piece, half an inch long, broken from the edge of one valve. Mussels and clams close their shells so tightly that it would perhaps be impossible for a bird to insert his beak, however knife-like in shape and hardness, between the valves in order to force them open; therefore I believe the Courlan [Limpkin] first feels the shell with his foot whilst wading, then with quick dexterity strikes his beak into it before it closes, and so conveys it to the shore. Otherwise it would be most difficult for the bird to lift the closed shell from the water and to carry it to land; but supposing it could do this, and afterwards succeed in drilling a hole through it with its beak, the hole thus made would have jagged edges and be irregular in shape. But the hole is, as I have said, angular and with a clean edge, showing that the bird had just thrust his beak half an inch or an inch between the valves, then forced them open, breaking the piece out during the process, and probably keeping the shell steady by pressing on it with its feet.

We have never seen Limpkins use their feet either to locate mussels or to brace them for extraction. All of the shells we have seen, opened without blows (Figure 15), had extremely little damage, only slight chips to the edges of the valves; and the shell damage Hudson described is the kind we observed in shells opened by blows. However, shells opened by blows do not always show extensive damage. For instance, in Figure 9, the bottom shell which received 29 vigorous blows is only slightly damaged at the lips of the valves.

We found evidence only once of a Limpkin failing to open a mussel. On 28 February 1968, at a Limpkin feeding station along the Tamiami Trail near Coopertown, we picked up a massive unopened specimen of *Uniomerus obesus* which showed typical but slight Limpkin damage to the posterior end.

Extracting Snails from Shells

A Limpkin carries a snail to shore gripped in a variety of ways (Figures 16 and 17). It positions the snail on a substrate with the aperture facing upward and the spire pointing toward its feet (Figure 18). With the bill the bird either immediately sets to work removing the snail from its shell or it first drives one or more, sometimes as many as eight, blows into the aperture (Figure 19,a). After a blow the Limpkin often raises its head with the snail impaled on the tip of the bill with the spire pointing down (Figure 19,b). This spire-down position of the snail was invariable in over 25 observations of nine or 10 different birds in five localities. The Limpkin then replaces the snail in the substrate and extracts the soft parts.

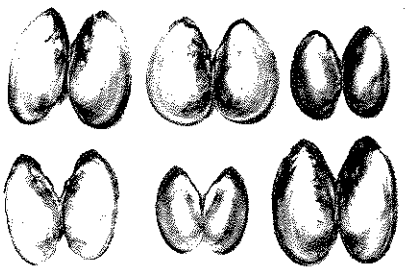

Figure 15. Shells of the mussel, *Anodonta cowperiana*, opened by Limpkins without blows. Note that the damage, if any, is very slight—merely small chips on the edges of the valves. Saddle Creek Park.

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