A Comparison of Foraging Techniques of Brown Pelicans and Brown Boobies in Sandy Ground Lagoon, Jost Van Dyke, B.V.I.

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ABSTRACT.—Brown Pelicans (Pelecanus occidentalis) fishing in a shallow (~1 m deep) lagoon on Jost van Dyke, British Virgin Islands, followed a well-known pattern in which the birds searched for prey from the air at heights of about 10 m or more. On sighting a target, they usually wheeled and made a near vertical plunge-dive. In marked contrast, Brown Boobies (Sula leucogaster) searched for prey in the lagoon by floating on the surface and putting their heads repeatedly into the water. Once a target was selected, a booby would remove its head from the water, take off, and fly at a height of 1 m or less for one to several meters before diving at a very shallow angle. This sequence was usually repeated rapidly many times, so that the mean diving frequency for feeding Brown Boobies was almost 50 dives/10 min compared to 12 dives/10 min for the pelicans. Although dense schools of small fish were extremely abundant in the lagoon, the diving effectiveness of the boobies was only 3% compared to 44% for the pelicans. This result contrasts with earlier anecdotal accounts of feeding success by Brown Boobies, but it is consistent with the optical challenges inherent in the shallow angle diving practiced in the lagoon.

INTRODUCTION

From 17 to 29 April 1995, we observed groups of Brown Pelicans (Pelecanus occidentalis) and Brown Boobies (Sula leucogaster) feeding on dense schools of small fish in Sandy Ground Lagoon on the island of Jost van Dyke, British Virgin Islands. The foraging techniques and success rates of the two species were strikingly different although they were exploiting the same very abundant food resource. While the Brown Pelican has been the subject of several studies that describe its feeding techniques in detail (Orians, 1969; Schreiber et al., 1975; Brandt, 1984; Coblentz, 1986; Carl, 1987; Arnqvist, 1992), feeding by the Brown Booby has received little attention (Bent, 1964; Nelson, 1978; Schreiber and Clapp, 1987). We are not aware of a previous quantitative description of the Brown Booby feeding technique we observed or any comparison of the success resulting from the different foraging behavior of the two species displayed.

The Setting

Sandy Ground Lagoon lies between a sandy beach and a fringing coral reef that stretches between two rocky headlands. The lagoon is about 240 m long and 15-20 m wide. The tide range is on the order of 0.5 m and the water depth is about 1 m at low tide. The lagoon contains large amounts of coral rubble. The sandy beach is about 20 m wide and grades into a 10 m wide grassy area that lies at the foot of a steep hillside. There are eight small houses scattered over the hillside.

At the start of our visit, there were 10-20 adult boobies and a similar number of mixed adult and immature pelicans around the lagoon. While we had seen similar numbers of pelicans fishing in the lagoon during three previous visits to the island, the number of boobies was surprising. In previous years only one or two boobies per day fished the lagoon. During the first five or six days of our study, when the birds were feeding most actively, the waters of the lagoon contained extremely dense and numerous schools of small (about 4-8 cm) fish that appeared to be a mix of silversides, dwarf herrings, and anchovies. As noted by Humann (1994), these names refer to any of a group of about ten different species that mix together in schools and “are virtually impossible to distinguish underwater.”
Unfortunately, it was beyond our means to obtain a quantitative measure of fish abundance. When float-swimming slowly through the lagoon, we were almost constantly surrounded by schools of fish. After this time the abundance of fish declined to levels we had observed in previous years. In very rough terms, during a 30-min swim we encountered 2-3 schools. The number of boobies also declined sharply after the first five days until only one or two birds visited the lagoon each day. When not fishing the boobies commonly roosted on the rocky headland at one end of the lagoon. The pelicans floated on the water, roosted on the headlands, stood on the beach or on pieces of coral at low tide, or flew out of sight around the headlands or over the hill.

Observations

The small size of the lagoon made it easy to use a pair of 10 × 50 binoculars to observe individual birds as they flew and dove anywhere in the area. Perhaps because of the houses overlooking the lagoon and the common passage of small motorboats just outside the reef, both species of birds seemed oblivious to our presence. All observations were made between 0800 and 1700. While there are a few reports of Brown Boobies (Nelson, 1978; Anderson et al., 1991) and Brown Pelicans (Robert and McNeil, 1989) feeding at night, both species became active feeders only as the sun angle increased and reflection decreased. Carl (1987) found that Brown Pelicans dove with the sun behind them, and our less quantitative observations agreed with his. During the morning the pelicans generally (but not always) dove from the east, the side of the lagoon framed by the reef. In late afternoon they more commonly dove from the west or beach side of the lagoon, and feeding declined relatively early because the high hill blocked off the direct light on the lagoon some hours before sunset.

We also observed the birds on and below the surface of the water by floating slowly up to them while remaining submerged just below the surface using snorkels and face masks. In this way it was possible to approach within a meter of either species. We measured the diving effectiveness (proportion of dives resulting in a prey being secured; Brandt, 1984) of 49 mature or juvenile pelicans and 20 adult boobies over a six-day period. In all, we observed 372 pelican dives and 623 booby dives. Since we could not identify individual birds, we do not know how many different individuals we observed or if we biased our sample by following some individuals more often than others. The same problem has been present in previous studies (Orians, 1969; Brandt, 1984; Arnqvist, 1992).

RESULTS AND DISCUSSION

Foraging Behavior

As noted by Orians (1969) and others, the Brown Pelican is "ideally suited" for feeding studies of this kind because its dramatic plunge-dives are only executed when hunting, and it is easy to tell from a pelican’s behavior if it has been successful in capturing prey. As described by Orians (1969), “An unsuccessful bird pulls its head out of the water with the bill open, allowing water to drain out immediately. A successful bird . . . raises its bill slowly, holds it pressed against its breast while the water drains out, and then swallows its prey with a tossing motion of the head.”

The feeding behavior of Brown Pelicans has been carefully described (Schreiber et al., 1975), and the birds on Jost van Dyke were not exceptional in this regard. Briefly, the birds generally flew slowly along the length of the lagoon at heights of 10 m or more searching for small fish in the water below. If a bird sighted a suitable target, it would usually wheel as described by Cobeltz (1986) and then plunge. On the basis of their detailed observations, Schreiber et al. (1975) concluded that Brown Pelicans dive for individual fish even when they are in schools. In some cases, pelicans would take off from the water, flap their wings vigorously, and rise only a few meters into the air before plunging at a steep angle. This behavior was confined to immature pelicans in our sample, and it was usually not successful. Some birds repeated this quick ascent, wheel, plunge sequence several times in quick succession.
The most detailed descriptions of feeding by Brown Boobies were reported by Bent (1964) based on accounts given by J. J. Audubon in 1840 and by H. Bryant in 1861. Their descriptions differ markedly with regard to the grace of the bird, but both suggest that the booby is a skillful and successful hunter:

The flight of the booby is graceful . . . if you follow an individual, you see that it suddenly stops short, plunges headlong into the water, pierces with its powerful beak and secures a fish, emerges again with inconceivable ease, after a short interval rises on wing . . . .

J. J. Audubon

The booby is, I think, the most expert diver that I am acquainted with; no matter in what position it may be, whether flying in a straight line, sailing in a circle, just rising from the water, or swimming on the surface, the instant it sees its prey it plunges after it. I have frequently seen one dive from the wing, rise to the surface, and dive in rapid succession five or six times; and on taking flight again, dive before it had risen more than two or three feet from the surface, and perhaps catch a dozen fish in the space of a minute. There is nothing graceful in its style; it is apparently work and not pleasure.

H. Bryant

The Brown Booby foraging behavior that we observed in the lagoon was very roughly consistent with Bryant’s description, but the outcome of the behavior was quite different. The boobies virtually always flew less than 1 m above the surface of the water and at faster speeds than the pelicans. They entered the water rapidly at a very shallow angle, disappeared below the surface, and then reappeared some distance away (perhaps a meter) after a few seconds. Nelson (1978) quotes an earlier description of the Brown Booby as a “torpedo” diver. By using binoculars it was easy to see if a booby had been successful because the small fish protruded across the bird’s sharp narrow bill. It was critical to observe the boobies as soon as they surfaced, however, because it required only a few seconds for them to flip a fish around and swallow. We never saw a booby catch more than one fish in a dive.

We also never saw boobies land directly on the water as the pelicans commonly did. The boobies always made the transition from flight to floating by means of their characteristic short, shallow slicing dive. Once the boobies were floating on the water they repeatedly put their heads under water for periods lasting less than a minute. By observing the birds from under water it was apparent that they were examining the dense schools of small fish, because the birds swung their heads rapidly left and right as if scanning the fish that were often swimming in great numbers only 25-50 cm away. On several occasions we saw a booby propel itself rapidly forward using its webbed feet while keeping its head below water. Similar behavior has been reported in the Caribbean (Nelson, 1978). Our impression was that a bird pursued an individual fish. While these paddle pursuits were never successful, it seems clear that the Brown Booby’s eyes (like those of numerous diving birds) are capable of accommodation to deal with different refraction in air and water.

We did not discover the characteristic feature of a fish or group of fish that would motivate a booby to engage in its remarkable foraging behavior, a series of rapid take offs and shallow plunges. In this sequence, a bird would remove its head from the water and very quickly take off on a short, low level (<1 m) flight of one to several meters before it dove again. In many cases the bird would take off again immediately after surfacing from the dive, while in others it would surface, puts its head under water, then take off. In the most extreme case we observed, one mature Brown Booby made 70 dives in ten minutes, thus allowing an average of only 8.6 seconds between dives.

Diving Frequency and Success

We counted the number of dives made by 21 mature or juvenile pelicans and 9
adult boobies during timed 10-min. intervals on days when the birds were actively feeding. The very obvious difference in diving frequency made it unnecessary to collect a larger sample. Since the data were not normally distributed and the sample size was small, we tested for a statistically significant difference between the mean diving frequency of the boobies (48.8 dives/10 min ± 3.9 S.E.) and the pelicans (12.0 dives/10 min ± 3.2 S.E.) using a non-parametric analysis of variance, the median test (SAS 1982). Since $X^2_1 = 12.43$, $P < .0005$, the difference in the means was highly significant. The most frequent diving pelican was an adult that made 36 dives in 10 min compared to the booby noted above that made 70 dives in 10 min. While some pelicans made as few as 1-2 dives/10 min when feeding, the least active booby made 22 dives in 10 min.

Although the two species often dived or floated within a few meters of each other, we saw no obvious interactions, such as the interference competition or kleptoparasitism between Brown and Blue-footed Boobies described by Tershy and Breese (1990). It often seemed as if the boobies moved to areas in the lagoon where the pelicans were fishing, but we could not establish this with certainty.

The mean diving effectiveness of the pelicans in our mixed-age sample (44% ± 5.6 S.E.) was significantly ($X^2_1 = 26.96$, $P < 0.0005$) greater than that of the adult boobies (3.0% ± 12.8 S.E.). Our results for the mixed group of adult and immature pelicans are roughly comparable with those of previous studies (Orians, 1969; Brandt, 1984; Carl, 1987; Arnqvist, 1992).

The very low rate of prey capture associated with the booby’s frenetic foraging technique is interesting, especially since their prey were extremely abundant. It appears that the Brown Booby is poorly suited to forage in shallow water. While the pelican can make an almost vertical plunge dive from a height of 10 m or more that does not carry it very far below the surface, the much more compact and streamlined boobies would almost surely have struck the bottom of Sandy Ground Lagoon if they had made such a plunge. Nelson (1978) described Brown Boobies diving into deeper water from a height of 10-15 m.

The shallow “torpedo” dive practiced by the boobies presents them with the difficulty of refraction and parallax. Carl (1987) illustrated the problem well in discussing pelican diving strategy, and emphasized as the dive angle becomes smaller relative to the water surface, refraction increases the discrepancy between the position of a prey item and its apparent position. Perhaps for this reason, we never saw a booby capture a fish on its first dive following a skimming flight of more than a few seconds. The “first dive” seemed only to get the bird onto the water. Successful “dives” came almost entirely as part of the sequence described earlier in which a booby looked around with its head under water and then made a lunge-like take off and dive. It seems probable that the visual acuity of the Brown Booby under water is sufficiently good that it can pick out a target one to several meters away. Unfortunately for the boobies, however, small fish are often rapidly moving targets, and the few seconds required to withdraw the head, take off, fly, and dive usually left the birds where the fish had been. This result contrasts markedly with the diving success attributed to the Brown Booby in earlier descriptions, but our observations are consistent with the optical challenge of shallow diving. In deeper waters the headlong plunge described by Audubon may result in a higher rate of success.

As a final point, we should note that the very low diving effectiveness of the Brown Boobies in the lagoon does not necessarily mean that their foraging was less energy efficient than that of the pelicans. It would be complicated to compare the energetic costs and benefits of the different types of behavior. However, the fact that the number of boobies fishing in the lagoon dropped sharply after the exceptionally large number of fish in the lagoon returned to more typical conditions suggests that the booby’s ineffectual shallow water foraging may only yield a net energy gain when prey are very abundant.

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LITERATURE CITED


