OBSERVATIONS ON FEEDING ECOLOGY AND BEHAVIOR OF COMMON TERNS

MICHAEL GOCHFELD

Many field biologists have focused attention on various aspects of the feeding behavior and ecology of terns. Despite the difficulties experienced by terrestrial ornithologists in studying a primarily marine phenomenon, an impressive literature has accumulated on foods utilized, territorial behavior, learning, and capture (Ashmole 1968, Ashmole & Ashmole 1967, Buckley & Buckley 1974, Dunn 1972, LeCroy 1972, Lemmetyinen 1973, Nisbet 1973, and others). There are also numerous studies on the feeding of chicks and their development, topics not considered here.

During studies on the breeding biology of Common Terns *(Sterna hirundo)* at Jones Beach, Nassau County, I have studied several aspects of the feeding behavior of adult terns. Common Terns capture small fish by diving from heights of from one to about seven meters above the water, often submerging momentarily. The height from which the dive is initiated may increase with the depth at which the fish occur (Dunn 1972). After capturing a fish, a tern either swallows it or carries it in the beak to feed to its young.

I present here observations relevant to the following subjects: social enhancement of feeding, feeding success studies, capture of more than one fish, and transport of fish to the young.

SOCIAL ENHANCEMENT OF FEEDING

Social enhancement refers to improved or accelerated performance of some task by one individual, when other individuals are engaged in the same task. Although ethologists use the term to refer to the stimulation of one individual by the performance of another, (as for example in humans when yawning occurs contagiously), enhancement may also involve improving one's performance by learning how or where others are being successful. Ward and Zahavi (1973) have proposed that aggregations of birds function primarily as "information centers," allowing individuals to locate patchily distributed food. For example, in species that form large nocturnal roosts, birds that have been relatively unsuccessful at locating food the previous day may follow successful birds to good feeding sites the next day. Another example of information exchange in a colony is the dance of the Honey Bee *(Apis mellifera)* which conveys information on the

location of food to other members of the hive (von Frisch 1967). Recently Emlen and Demong (1974) have suggested that the lines of adults going back and forth from colony to feeding grounds are important guidelines for recently fledged Bank Swallows *(Riparia riparia).* They suggest that this is an important selective factor favoring synchrony in swallow colonies, since it is best to fledge at a time when there is a great number of adults moving into and out of the colony for feeding. If information exchange is indeed an important aspect of coloniality, then aggregations of birds should form where food is patchy rather than homogeneously distributed. Moreover, the patchy food source must contain enough food to sustain a large number of individuals; thus Horn (1968) emphasized that coloniality is an adaptive response to the occurrence of an abundant but patchy food source, and he noted that birds in an aggregation would make more efficient use of such a source than if they were uniformly distributed.

On Long Island, Common Terns often feed in large flocks over shoals of fish, and their food can be considered patchy and locally abundant. It is difficult, however, to know whether food is a limiting resource for terns; that is, whether the population size and reproductive success are directly determined by the amount of food available. That populations are limited by food is a basic assumption in many papers on theoretical ecology, but Austin (1946) stressed that this assumption has rarely been documented. There is evidence linking food shortage to starvation or retarded growth of terns in several studies (Austin 1933, LeCroy & LeCroy 1974, Langham 1972, Kremer 1973). Ashmole (1963) has discussed in general terms the role of food as a limiting factor for sea birds.

At Jones Beach, there have been several occasions when a shortage of fish has been evident. In some seasons there are periods of up to three weeks when the birds feed extensively on crustaceans such as various shrimps or Mole Crabs *(Emerita talpoida),* foods which I have found unsatisfactory for sustaining growth in laboratory-reared Common Terns. One can infer that when Common Terns feed extensively on crustaceans it is because fish are scarce or difficult to locate.

If the distribution of fish is patchy and the shoals of fish are mobile and unreliable, terns may have to cover very large areas of sea before finding food. Terns would therefore benefit from the opportunity to judge the success of other birds. Although Common Terns

probably spend much of their time feeding within 4 miles (6.4 km) of their colony sites (Austin 1946), this encompasses an area of about 72 sq. km. A tern leaving the colony site on a foraging trip after spending several hours brooding chicks, must choose its direction correctly if it is to locate a school of fish. If it has an opportunity to observe neighboring terns arriving at their nests with fish, it can simply follow outward the line of incoming terns, eventually arriving at a feeding ground. In a large colony exploiting a localized food source, a continuous stream of birds would be evident. A dramatic example of this was noted at Jones Inlet, Nassau Co., on 29 May 1960, when a constant movement of terns was noted along a line extending from the West End Beach colony, straight out to an area about 3 km. south of the mouth of the inlet. Outgoing birds flew about 5-10 meters above the water, while birds returning with fish flew low (mainly under 5 meters) over the water. I timed the movement of birds, and found about 35-40 birds per minute returning with fish. This feeding area was perhaps not out of visual range of birds leaving the colony, but the observation illustrates that such feeding lines do occur and could assist birds in locating a more remote food source. One should look for such lines in pelagic species, such as the Sooty Tern *(S. fuscata),* that frequently feed many miles from the breeding grounds.

My observations at the Common Tern colony have not demonstrated that departing birds actually do observe and respond to birds arriving with fish. Birds that arrive at a territory with a fish and then leave immediately, presumably retrace the route they have just flown. It would be most fruitful to observe birds that have been on the nest for several hours, for these would benefit most from observing the direction of arrival of successful terns.

FEEDING SUCCESS STUDIES

Beginning with Orians' (1969) comparison of feeding success in adult and juvenile Brown Pelicans *(Pelecanus occidentalis),* the study of age differences in foraging success has interested several groups of field workers (Recher & Recher 1969, Salt & Willard 1971, Dunn 1972, Buckley & Buckley 1974, Gochfeld MS). Most of this work has involved terns, particularly those species that hold or transport the fish in the bill before swallowing. The prey is thus readily visible and an observer can determine whether a dive has been successful or unsuccessful. Insectivorous birds are much more difficult to study since in many cases the prey disappears almost instantly and is of

such a small size relative to the beak that one has difficulty in seeing whether a capture has occurred.

The following example indicates that one cannot always rely on the external visibility of the prey. On 20 June 1974, I watched Common Terns feeding over a shoal of Sand Launce *(Ammodytes americanus),* about 30 meters off the Jones Inlet jetty. At this close range it was possible to observe their behavior in detail. The birds were capturing fish ranging in length from 4 to 8 cm. While studying feeding success rates, I noted four instances in which terns dove, reappeared with small fish, and then immediately swallowed the fish, even before shaking the water from their plumage. The swallowing occurred less than two seconds after the birds surfaced, and had they been further away, these dives would have been scored by me as failures. The possibility that some captures may go undetected should be considered in any study of feeding success rates.

This observation raises the question of why a few birds swallowed the fish rather than carrying them away. Parent terns that capture a fish stop feeding and carry the fish back to the young. There is some crucial stimulus associated either with the presence of the fish in the beak or the successful capture event that causes the change in behavior. A small fish might be an inadequate stimulus to inhibit swallowing, and the terns I saw swallow fish immediately may simply have captured very small fish. Alternatively they may have been birds without young. Unfortunately, it was not possible to trace these unmarked birds in the milling group of terns to see whether they later left the flock with fish.

CAPTURE OF MORE THAN ONE FISH

Some species, such as the Common Puffin *(Fratercula arctica)* carry fish in their beaks and carry several fish at once. Others, such as some terns and all gulls, carry food internally and can therefore transport relatively large quantities and then regurgitate partially digested food for their young. Common Terns do not carry food internally, and generally carry one fish at a time in the bill. This seems a wasteful procedure and probably limits the birds to fishing close to the breeding site. One might predict that selection would favor the transport of more than one fish at a time. Hays *et al.* (1973) discuss such behavior in terns, and note that only 1.8% of feeding visits involved more than one fish (up to nine fish in one case). How such additional fish are captured remains uncertain.

On 20 June 1974, I twice saw adult Common Terns dive with their

bills empty and emerge with two fish. It is likely that the fish were close together and that the capture of two was simultaneous and fortuitous. In each case the birds returned to the colony site immediately. The fish were *Ammodytes* less than 5 cm. in length, and Hays *et al.* (1973) note that when several fish are carried at once they are usually small. My observation of essentially simultaneous capture of two fish does not indicate how a tern might catch as many as nine fish, and a more active process of actually chasing additional fish seems likely. It would be valuable to determine whether any individuals habitually catch more than one fish per foraging trip.

TRANSPORT OF FISH TO THE COLONY

Palmer (1941) noted that Common Terns regularly carried fish to the breeding colony with the head of the fish pointing to the same side. In evaluating cues by which young Common Terns learn to swallow fish head-first (Gochfeld 1975), I examined the constancy of head orientation of the fish carried into the West End colony. On 20 June 1974, I observed 36 arrivals of birds with fish. In 14 cases the head of the fish pointed to the right, in 10 cases to the left, and in 12 cases, the direction was not noted. Two hours later I watched the terns fishing in the inlet, and I noted 119 fish being taken back to the colony. Of these, the heads pointed to the right in 57 cases, to the left in 33 cases, and in an undetermined direction in 29 cases. I compared these two samples in a 2 x 2 contingency table, and the direction of transport did not differ ($X^2 = .27$, $p > .10$). With a binomial test the first sample did not differ from equality ($p > .20$) while the second sample did ($p < .02$). Thus even when the birds were feeding over a shoal of fish there was variation in the direction in which the fish were held. Immediately after capture, terns often manipulate the fish so as to grip them behind the head. However, the fact that there was no significant difference between the direction of the fish at the time of capture and on arrival at the colony indicates that the birds were probably not rearranging the fish during transport.

CONCLUSION

These anecdotal accounts suggest several studies that would be useful in determining how terns locate and exploit different prey. Not only do ornithologists have trouble locating feeding grounds, but terns themselves may experience difficulty. It is not known whether they are particularly good samplers, nor even whether they show strong preferences for certain fish, but Austin (1933) and Palm-

er (1941) both remark that *Ammodytes* is the preferred food of Common Terns on the New England coast.

It would be interesting to determine whether flight lines are more likely to form as birds are forced to feed further from their colony sites by a shortage of fish nearby, and it would be valuable to learn whether the use of such lines increases the birds' feeding success. The main limitation at present seems to be our inability to locate and sample the food supply at the time that the birds are exploiting it.

The possibility that differences in tern behavior could be correlated with the species, size, or density of the fish being sought is very attractive. There are many difficulties involved in studying the feeding behavior of marine birds (I.C.T. Nisbet, pers. comm.), but some of the problems do lend themselves well to careful descriptive observations. In many cases it is essential to have birds marked for individual recognition. I have been particularly interested in learning whether the manner in which adults arrive with fish or the orientation of the fish in the bill, influences the ease with which the chick learns to seize and swallow the fish.

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Department of Biology, Queens College, Flushing, N.Y. 11367