Short Communications

Observations of Feeding of a Little Penguin *Eudyptula minor*

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Foraging behaviour in the Little Penguin *Eudyptula minor* has been qualitatively described by a number of authors (e.g. Dove 1910; Roberts 1951; Oliver 1955). In all cases the technique used has followed a similar pattern: the penguin locates a school of fish, accelerates and proceeds to swim around the school in an ever-diminishing circle and then swims through the centre of the school, grabbing at fish as it passes. This method of feeding is also employed on schooling fish by the Jackass Penguin *Spheniscus demersus* (Wilson 1985) and the Magellanic Penguin *S. magellanicus* (Boswall & MacIver 1975).

This paper describes foraging patterns employed by a solitary Little Penguin at the mouth of Cockle Creek, south-east Tasmania (43°35'S, 146°53'E). The Penguin was feeding on small (*c.* 2 to 3 cm in length) schooling fish of the Order Atheriniformes in clear water less than 1 m deep on an incoming tide. Cockle Creek mouth is approximately 30 m wide with a sand substratum and without any macrophytic vegetation. Observations were made (from 1620 to 1650 EST on 4 April 1986) whilst standing on a bridge crossing the creek. The bird was not obviously perturbed by observers standing on the bridge above it.

In the absence of the Little Penguin, the numerous atherinids swam rapidly through the water in alternately contracting and widely expanding schools. When the Penguin approached, the schools immediately compacted into dense, tight, rapidly weaving formations. The Penguin accelerated and rapidly swam in a diminishing circle around a school. Following an average of 5.7 ± 0.2 (*s.e.*) circlings (n = 32) the Penguin would attempt to capture prey by one of three manoeuvres.

TABLE 1 Number of prey passes and success rates of the four feeding manoeuvres employed by the Little Penguin at Cockle Creek, south-east Tasmania.

	Feeding manoeuvre				
	a	b	c	d	Total
No.of prey passes	17	8	7	18	50
Successful captures	11	4	3	11	29
Success rate (%)	65	50	43	61	58

It would: (a) swim through the bunched school snatching at fish, or fishes if unsuccessful, and then continue to circle the school; (b) swim through the school and pursue (for a distance of up to 5 m) single individuals or small groups of fish that became separated from the main school, after which the bird would return to circling the main school; and (c) the bird would seize fish breaking away from the school during the circling process. Table 1 outlines the number of occasions each manoeuvre was performed and their success rates.

Another foraging manoeuvre (d) was employed in shallow water (< 40 cm deep). Here the Little Penguin did not circle the fish, but accelerated rapidly and pursued the fish school in a direct line. Frequently the water was so shallow that the upperparts of the bird were protruding above the surface and the Penguin had to beat its flippers on the sand to maintain momentum. This strategy produced a 61% success rate (Table 1). The mean success rate for all manoeuvres was 58% with manoeuvre (c) being the least successful and manoeuvre (a) the most successful (Table 1).

Little Penguins were also observed from a dingy feeding in Rocky Bay (into which Cockle Creek flows) in water less than 8 m deep (measured by lead line). Penguins allowed close approach and appeared unperturbed by the boat. In sections of Rocky Bay (3 to 8 m deep) Penguins employed feeding manoeuvre (a), whereas along the sandy shoreline of Rocky Bay in water less than 1 m deep Penguins employed manoeuvre (d). In all cases Penguins were observed foraging singly and each successful manoeuvre resulted in the capture of a single fish, which was then swallowed underwater.

The Little Penguin feeds on prey that has several adaptations for avoiding predation, including aggregative behaviour that reduces the probability of predator-prey encounter (Cushing & Harden-Jones 1968), and schooling (Pitcher & Partridge 1979) where aggregations are highly organised so that the prey can react to minimise predation after they are discovered (Partridge 1980). Thus, when approached by a Penguin, a school compacted and inten-

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sified weaving occurred. Such prey behaviour produces either a 'confusion effect' of many closely spaced and intermingling prey upon the sensory receptive capabilities of a predator (Hobson 1968) or provides insufficient time for the predator to align itself with an individual prey for a successful strike (Major 1978). In such situations predators feed on individuals that make mistakes (Major 1978).

In the present situation mistakes appeared to be made by: (a) individuals moving too far away from the school (feeding manoeuvre c) i.e. an individual at the edge of the encircled school falling behind or one in the lead moving too far ahead, or an individual turning too widely or too sharply (b) individuals moving too slowly (manoeuvre a) when the Little Penguin rushed the main school or swimming in a different direction to the rest of the school (manoeuvre b); The pruning of marginal or peripheral individuals is widely reported in predator-prey interactions (e.g. Milinski & Curio 1970; Hamilton 1971; Major 1978).

Because penguins mostly swallow their prey underwater, few observations have been made in the capture success rate (Siegfried *et al.* 1975). In this study the overall success rate, all feeding manoeuvres combined, was 58%. The observed success rate may in part be due to the Little Penguin feeding in shallow water, which possibly reduced the manoeuvrability of the target species.

The Little Penguin attacked fish schools from the side rather than from underneath, which is contrary to observations made on Jackass Penguins (Rand 1960) and captive Humboldt Penguins *Spheniscus humboldti* (Zusi 1975).

The feeding techniques employed by the Little Penguin when feeding on small schooling fish may be similar in deeper offshore waters. This is supported by observing Penguins using the feeding manoeuvre (a) in water up to 8 m deep. The direct chasing of fish (manoeuvre d) may also occur when Little Penguins pursue prey along the edge of submerged rock ledges and sand banks.

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