FEEDING METHODS OF THE SHORT-TAILED SHEARWATER *PUFFINUS TENUIROSTRIS*

In principle there are four categories of feeding methods performed by procellariiform birds. These are: 'plunging' from the air to capture prey at or below the surface; plunge-diving from the surface; feeding while settled on the surface; and feeding while flying (Ashmole 1971). The Short-tailed Shearwater or Muttonbird is known to be a surface feeder, taking crustaceans, small fish and small cephalopods (Ashmole 1971). Skira (1979) reported that the Muttonbird is capable of feeding underwater, and noted that birds have been caught in nets set at 20m depth. Despite these observations there have no published accounts of the feeding methods of the Muttonbird. This article describes the behaviour of Muttonbirds feeding in D'Entrecasteaux Channel, Tasmania.

On the 31 March 1980 an assembly of several thousand shearwaters (mainly *Puffinus tenuirostris*) was observed off Helliwells Point, about 35 km south of Hobart. The Muttonbirds congregated in densely packed rafts on the surface. They were observed for about forty minutes often at distances as close as 3 m from the vessel. I describe observations made from the upper deck of the research vessel Penghana, using a pair of 4 × 45 binoculars. A 0.25^2 m plankton net (270μm) was towed several times beneath the rafts of birds and the catches qualitatively analysed.

Two principal methods were observed, namely 'underwater' and 'surface' feeding:

Underwater

Muttonbirds from each raft moved in a tight formation with individuals flying up from the rear to dive in again at the front of the flock. They dived either from a sitting position on the surface or by plunging in from one to two metres above the surface. Most of the Muttonbirds diving from a height entered the water at an angle estimated to be between 45° and 75° to the horizontal, with the wings held approximately one-third of the full extension away from the body and with the feet held under the tail.

Once submerged, individuals were estimated to remain underwater for periods of up to twelve seconds. Birds would reappear at the surface up to 20 m from the site of entry, indicating that they do not depend solely on their initial air speed for momentum underwater. They surfaced at a similar angle to entry, often bursting out of the water directly into flight.

Some birds approached the water as described previously for plunging but instead skimmed along the surface using their breasts and feet as cushions. These birds did not settle, but began to fly again by flapping the wings rapidly and pattering their legs along the surface. This behaviour only occurred when the birds were moving directly into the wind, holding the wings above their backs for stability.

Muttonbirds diving from the surface turned to face into the wind. This was followed by two or three full flaps of the wings to produce a preliminary jerk of the head and breast. The wings were then folded to about one-third of full extension and the birds dived into the water at approximately 45° in a forward arching movement. As the birds disappeared beneath the surface the legs and wings began to move. It was noticed that some Muttonbirds stayed beneath the water for approximately eight seconds (*cf* twelve seconds for birds diving from a height) and reappeared up to 10 m away from the site of entry. On breaking the surface the birds would either quickly roll their body forwards and dive back under the water or settle on the surface and extend the head upward, flapping the wings and ruffling the feathers.

Surface

Muttonbirds exhibited two types of feeding activities while settled on the surface, namely 'surface-seizing' and 'hydroplaning'. When a Muttonbird is continually darting its head in and out of the water it can be said to be surface-seizing. After a period of surface-seizing the Muttonbird extended its head high into the air while flapping its wings. This suggests that the bird captured and retained food in its beak and then swallowed it above the surface. In surface-seizing, Muttonbirds did not swim rapidly but continually darted their heads in and out of the water at different places.

A specialised filtering technique known as 'hydroplaning' (Murphy 1936) was exhibited by feeding Muttonbirds. The birds held their wings raised above their backs and about two-thirds extended. The head was then extended forward so that the beak skimmed the surface of the water. In this position the Muttonbird was also able to thrust its head beneath the surface. The feet were used as paddles to propel the bird slowly forward. The wings did not appear to move but may be used for stability as they were held high above the water. This mechanism of feeding was the least used of the observed types and lasted only three or four seconds at a time.

Like many other seabirds, the feeding methods of Muttonbirds are diverse. The mode that is used is probably determined by the type and availability of food, as is the case with the Dove Prion *Pachyptila desolata* (Prince 1980).

Kurada (1954) regarded the smaller species of the genus *Puffinus* as morphologically specialised for swimming and diving and my observations suggest that the Muttonbird is no exception. The dart-like entry of Muttonbirds is similar to the type of aerial diving practised by sulids such as the Gannet *Morus bassanus*. This type of plunge-diving presumably reduces the impact of the dive in the marked contrast to the 'crash-landing' of the Manx Shearwater *Puffinus puffinus* (Bourne 1976) and the 'belly-flops' and 'stalls' of the Sooty Shearwater *Puffinus griseus* (Brown *et al.* 1978). Plunge-diving may not only reduce impact but also may help Muttonbirds to dive deeper into the water.

The purpose of Muttonbirds skimming along the surface during flight is unclear. This behaviour may be associated with searching for food or feeding by skimming the beak along the surface, as with some terns and small petrels (Ashmole & Ashmole 1967).

The Muttonbird is known to use its wings while swimming underwater (Skira 1979). It appears from this study that the feet are also used. This may be similar to the underwater swimming behaviour of the Sooty Shearwater as described by Brown *et al.* (1978). They suggest that the Sooty Shearwater beats its wings underwater for acceleration on the descent and ascent and also during rapid horizontal swimming.

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REFERENCES

ASHMOLE, N.P. 1971. Seabird ecology and the marine environment. *In* Avian Biology 1. Färner, D.S. and J. King (Eds). New York: Academic Press.
ASHMOLE, N.P. & M.J. ASHMOLE, 1967. Comparative feeding ecology of seabirds of a tropical oceanic island. Peabody Mus. Nat. Hist. Bull. 24: 1-131.
BOURNE, W.R.P. 1976. Plunge-diving and porpoising by aquatic seabirds. Br. Birds 69: 188-189.
BROWN, R.G.B., W.R.P. BOURNE & T.R. WAHL, 1978. Diving by Shearwaters. Condor. 80: 123-125.
KURODA, M. 1954. On the classification and phylogeny of the order Tubinares, particularly the Shearwaters (Puffinus). Tokyo: Herald Co..
MURPHY, R.C. 1936. Oceanic birds of South America. New York: Am. Mus. Nat. Hist.
PRINCE, P.A. 1980. The food and feeding ecology of Blue Petrel (*Halobaena caerulea*) and Dove Prion (*Pachyptila desolata*). J. Zool. Lond. 190: 59-76.
SKIRA, I. 1979. Underwater feeding by Short-tailed Shearwaters. Emu. 79: 43.

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PESTICIDE CONTAMINATION OF BIRDS IN ASSOCIATION WITH MOUSE PLAGUE CONTROL

During the summer of 1979/80, a severe and localised plague of the house mouse *Mus musculus* occurred in the Carrathool District of the Murrumbidgee Irrigation Area (M.I.A.) of New South Wales. Plagues such as this irrupt periodically in south-eastern Australia (Saunders & Giles 1977) causing substantial losses to agriculture (Hopf *et al.* 1976). Producers faced with losses to standing crops from mouse damage often initiate broadacre control programmes using a variety of toxic substances as rodenticides, including insecticides such as endrin, dieldrin, parathion, mevinphos and DDT (Ryan & Jones 1972).

During the recent plague large numbers of birds were seen feeding on mice. On one property birds were seen feeding on the thousands of mice which had died as a result of control programme using endrin-treated wheat. This bait was placed in trails alongside roads and crops.

The most common birds were raptors, Brown Falcon *Falco berigora*, Australian Kestrel *Falco cenchroides*, Black-shouldered Kite *Elanus notatus* and Barn Owl *Tyto alba*. Of the opportunistic feeders, by far the most common were members of the Corvidae with smaller numbers of Straw-necked Ibis *Threskiornis spinicollis* and Black-backed Magpie *Gymnorhina tibicen*.

To determine levels of pesticide residues a sample of fifteen birds was collected in the area surrounding that treated with endrin bait. All specimens were obtained by shooting except for the Barn Owl which was a roadside kill. The sample was collected between 13 February 1980 and 6 March 1980. The last known application of endrin bait in the area was on 11 January 1980.

Mice were the predominant item in the gastrointestinal tract of seven of the fifteen birds. A Brown Falcon had a crop which was packed with the re-