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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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 remains of eleven mice.

Analyses were carried out using gas chromatography. All birds analysed contained pesticide residues although levels were generally low (Table I). DDT was found in fourteen of the fifteen birds analysed. DDT has been widely used in Australia since 1946 (Australian Academy of Science 1972) and is commonly used in the M.I.A. for the control of invertebrate pests. High levels of DDT have been found in ducks collected in the Barrenbox Swamp area of the M.I.A. (Olsen *et al.* 1980). Six birds contained traces of endrin. The use of endrin is not recommended in New South Wales and in the M.I.A. it has only minimal application.

Seven birds had detectable DDT in the gizzard compared to one with endrin, while in the intestine nine birds had DDT and only two had endrin. Food is stored in these organs only for short periods by birds of prey (Marshall 1960). Endrin, when consumed in sub-lethal quantities is also lost fairly rapidly from body tissue after exposure has ceased (Terriere *et al.* 1959). This suggests that the birds were being exposed to a persistent source of DDT while exposure to endrin was no longer substantial. Had the sample been collected during or immediately after the mouse poisoning programme, levels of endrin in the body tissues may have been much higher.

Poisoning of predators such as the raptors by pesticides has been widely reported (Lincer & Sherburne 1974) with most deaths occurring through secondary poisoning (Mills 1973). Sublethal levels of pesticide contamination can result in eggshell thinning and embryo death with consequent reproductive failure (Peakall 1970). Although it is illegal to use insecticides to control rodents it is probable that they will again be used in future mouse plagues.

The regulatory effect of predators such as raptors on population cycles of small mammals is often stressed. With the present lack of knowledge of what causes mouse plagues in Australia and how they can be controlled it is important not to jeopardize potential forms of natural regulation by the widespread and indiscriminate use of non-specific pesticides for rodent control.

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TABLE I

Residue Levels (ppm) of endrin and total DDT (including its metabolites DDE and DDD). Low levels of dieldrin (0.52-2.10 ppm) and heptachlor epoxide (0.15-0.48 ppm) were also detected in 2 and 3 birds respectively

Tissue	Fat		Liver		Gizzard		Intestine		
Residue	Endrin	DDT	Endrin	DDT	Endrin	DDT	Endrin	DDT	
Species									
Australian	n.d.	0.03	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Φ
Kestrel	2.2	2.56	n.d.	n.d.	n.d.	n.d.	0.03	n.d.	Φ
	0.55	1.72	0.61	n.d.	n.d.	n.d.	n.d.	0.03	
	n.d.	0.11	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	Φ
Brown	0.81	0.31	n.d.	n.d.	0.09	n.d.	n.d.	0.51	
Falcon	n.d.	3.9	n.d.	n.d.	n.d.	0.08	n.d.	0.02	Φ
	0.39	0.52	n.d.	n.d.	n.d.	0.02	n.d.	0.08	
	n.d.	4.34	n.d.	n.d.	n.d.	1.04	n.d.	0.15	
	n.d.	0.4	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	
	n.d.	1.1	n.d.	n.d.	n.d.	n.d.	n.d.	0.08	Φ
	–	–	n.d.	0.18	n.d.	34.2	n.d.	n.d.	
Black-	n.d.	n.d.	n.d.	n.d.	n.d.	0.19	n.d.	0.23	Φ
shouldered Kite	0.23	0.26	n.d.	0.11	n.d.	0.03	0.04	0.06	Φ
Corvid	–	–	n.d.	n.d.	n.d.	0.27	n.d.	n.d.	
Barn Owl	–	–	0.28	n.d.	–	–	–	–	

Φ Identifiable remains of mice in Gastro-intestinal tract.
n.d. = not detected.

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A METHOD OF AUTOMATICALLY RECORDING BEHAVIOUR AT THE NEST SITE

Direct observation of an adult bird's behaviour around the nest site is often very difficult and time consuming, and the presence of the observer may affect the bird's behaviour. Data may be required for estimating the time spent on incubation and brooding; and for determining the periods of activity when the parents feed their progeny. The problem of direct observation is greatest with crepuscular or nocturnal species such as the Australian Owlet-nightjar *Aegotheles cristatus.*

This paper suggests the possible use of a recorder that is reliable, portable and able to withstand the rigours of use in the field, and that would supplement direct observation. The recorder is a Stevens Digital traffic recorder — Model 7051. Its normal use is in preparing traffic censuses. It operates by a 12 volt rechargeable battery. With the recorder one can select pre-set time intervals, from five minutes up to sixty minutes in five minute intervals. Therefore a record of the sum of the number of events in the selected period can be obtained. The standard pneumatic switching gear is easily removed as it is unsuitable for this type of behavioural study. In its place a SUNX132 12 volt infra-red retro-reflective switch is attached by a 20m three strand wire cord. This switching gear can be adjusted to record any object passing in front of the infra-red beam. The only requirement of the apparatus is that the animal passes in front of the infra-red beam. In field trials from October 1980 to January 1981 the equipment was unaffected by the climate. The range of climates experienced at that time of year included heavy rain and a temperature range of 10° - 40°C. The advantage of this recorder is that it is not a new development, but a modification of a standard piece of equipment. Consequently the recorder has had extensive field trials and has proved to be serviceable in a variety of conditions. Previously published papers concerning recorders of bird behaviour have either been specially developed (Kendeigh & Baldwin 1930) or are somewhat questionable in operation (Marples & Gurr 1943). Marples & Gurr (1943) state that after continuous use of the wooden perch of their recorder was swollen by rain and ceased to operate. Although relatively expensive the recorder could possibly be borrowed from local authorities concerned with censusing traffic or from Engineering departments of tertiary institutions. The current cost for the 7051 recorder is $1485, but this model has since been superceded by the 7951 model at a cost of $1295 (pers. comm. Arthur Baker & Sons distributors, Melbourne).

Field trials were carried out in an area of woodland within the Ballarat College of Advanced Education campus (37° 35′S, 143° 55′E). Throughout this area a number of nest boxes have been established. In 1979 and 1980 some of these were successful as nesting sites for the Australian Owlet-nightjar and Crimson Rosellas *Platycercus elegans.* Each box was securely attached to a tree, approximately 4m above the ground. Once it had been established that a pair of birds was breeding in a particular nest box, the Stevens recorder was chained to the support tree (to prevent theft) and the SUNX132 retro-reflective switch attached beside the entrance hole. It was assumed that during incubating, brooding and feeding, only the parent birds would enter or leave the