PLASTIC PELLETS IN NEW ZEALAND STORM-KILLED PRIONS (*Pachyptila* spp.) 1958-1977

By P. C. HARPER and J. A. FOWLER

Since the problem of plastic pollution of the oceans was recognised in the early 1970s, there has been a steady increase in reports of seabirds ingesting plastic particles. This has culminated in an excellent synthesis of the subject by Day *et al.*(1985), who showed that most of the pellets from 50 species of seabirds were polyethylene fragments 3-5 mm in diameter, probably from larger pieces used in protective packaging, fishing buoys and other sources associated with fishing and marine shipping. Many other types of multicoloured plastics from toys, bottle caps, and clear plastic sheets have also been found in birds' gizzards. According to Day *et al.*, procellariiform species had the highest overall occurrence of plastic ingestion – 28 (90%) of the 31 specimens examined.

Plastic pellets occur in New Zealand waters, where Gregory (1977) found their abundance to be highly variable on New Zealand beaches: from 5-10/m in the more remote areas such as Ninety Mile Beach, Castlepoint, and the northern side of Farewell Spit, to dense in places close to industrial centres such as Petone, where pellets exceed 40 000/m. Gregory anticipated that New Zealanders would "sunbathe on 'plastic sand' beaches – a development already being approached at Oriental Bay in Wellington Harbour".

The aims of this paper are:

1. To report the incidence of plastic pollution in beach-wrecked prions, thus providing information on the unreferenced comments of Bourne & Imber (1982) that plastic pellets have been found in the stomachs of many beach-caste Salvins, Antarctic and Thin-billed Prions *(Pachyptila salvini, P. desolata* and *P. belcheri)* and Blue Petrels *(Halobaena caerulea)* in New Zealand.
2. To see whether the abundance of plastic pellets in prions has changed over the years.
3. To examine relationships between the number of pellets and the weight or age of prions.

METHODS

During the 21 year period from 1958 to 1977, PCH examined *Pachyptila* representing five species. The birds had been driven ashore dead or dying during the windy months of late summer and after the gales that sweep New Zealand in winter.

From 1979 of these 9247 birds, PCH removed the gizzards and proventriculi and examined them for plastic pellets. These birds were all freshly cast ashore on exposed coast from Otaki to Pukerua Bay, north of Wellington, and on the south Wellington beaches, including Petone and

Palliser Bay. A single wreck of 323 young Salvin's Prions about 30 June 1966 was large enough to examine statistically the relationship between the number of ingested plastic pellets and the weight of the birds.

TABLE 1 — Occurrence of plastic pellets in five prion species collected from New Zealand beaches, 1958-1977

Species	Age Class Imm*	Adult	Gizzards Examined	Number with Plastic Pellets Imm	Adult	% Total with Pellets Imm	Adult	Species Status
Broad-billed Prion *Pachyptila vittata*	170	140	310	18	33	10.6	23.6	NZ resident
Salvin's Prion *Pachyptila salvini*	651	12	663	133	0	20.4	0	Indian Ocean migrant
Antarctic Prion *Pachyptila desolata*	29	6	35	4	1	13.8	16.7	NZ subantarctic migrant
Thin-billed Prion *Pachyptila belcheri*	147	5	152	10	0	6.8	0	Indian Ocean migrant
Fairy Prion *Pachyptila turtur*	714	105	819	88	13	12.4	12.4	NZ resident
TOTALS	1711	268	1979	253	47			

*Immature = birds of the year; adults = all others.
Age determined by bone ossification, gonad condition, bill & feet shrinkage, measurements, plumage

RESULTS

Table 1 shows the occurrence of plastic pellets in immature and adult prions of five species. The Fulmar Prion *(P. crassirostris)* was not represented in the results because this prion is rarely beach-wrecked: its numbers are small, and it breeds on and remains near islands to the south or east of the country, whereas the prevailing winds are from the west.

All prions had an empty proventriculus and their emaciated condition clearly showed that they had not eaten for at least a week and probably much longer. The body weight of beached birds varies from 5% to 45% of that of adult breeding birds in good condition. An incubating Fairy Prion *(P. turtur)* will remain at its nest for five days before deserting the egg in order to feed (Harper 1976; 1980, pers. obs.).

Most of the migratory species examined were fledglings not long out of their nests. Of 663 Salvin's Prions, 651 or 98.2% were birds of the year, as were 82.8% of the 35 Antarctic Prions, 96.7% of the 152 Thin-billed Prions and 87.2% of the 819 Fairy Prions.

Whereas the glandular stomach was empty, gizzards contained squid beaks, an occasional fish otolith, and two types of abiotic gastroliths: small pieces of pumice and plastic pellets, both 2.5-3.5 mm in diameter.

Table 1 shows that, of the 1979 birds examined 300 (15.1%) contained plastic pellets. There was no statistically significant difference between the percentage incidence of pellets in immature (14.78%) and adult (17.54%) birds ($\chi^2 = 1.16$, NS).

Figure 1 shows the years in which enough data were collected on three species to make a useful comparison. Because of the small sample of both the Antarctic and Thin-billed Prions, these data have been omitted from Fig. 1 and 2. Some years produced more prion wrecks than others. This variability is probably due to three factors: variations in distant oceanic and local storms, food availability, and the yearly recruitment of young birds.

Figure 1 shows also the percentage of gizzards examined which contained plastic pellets. For all species there was an increasing trend over the study period, and for the Fairy Prion and Salvin's Prion, the trend was statistically highly significant ($r_s = 0.66$ and 0.82 respectively). The data for the three species are combined in Figure 2.

Table 2 shows the relationship between the body weight of birds and the number of pellets found. Of a sample of 323 Salvin's Prions cast ashore in June 1966, 78 birds (24.15%) contained pellets; the median number of pellets was 2.8, the mean 2.71 and the variance $s^2 = 3.54$. There is a statistically highly significant inverse correlation between the number of pellets in each bird and the mass of the bird ($r = -0.686$, $t = 8.27$, $P < 0.01$; counts of pellets were square-root transformed to normalise the distribution). The prion containing 13 pellets was also the lightest; its weight of 76 g represents only 48.4% of the mean 157 g departure weight of fledglings leaving a breeding station at Hog Island, Crozet Islands (Despin *et al.* 1972).

The mean weight of the 78 birds which contained plastic pellets was 93.1 g (range 76-114 g) and that of 244 birds which did not contain pellets 91.3 g (range 78-105 g). The difference is not statistically significant.

DISCUSSION

With their feeding methods prions can retrieve very small prey from the sea's surface. They can therefore easily collect plastic pellets floating on the water. We believe that, because the prions are so widespread and abundant, they may well be a useful natural monitor of plastic pollution in the southern oceans. Our data from three species suggest that prions began ingesting plastic pellets in the early 1960s and still do. The fact that both the Fairy and Broad-billed Prions do not range far would strongly indicate that plastic debris has been available to the birds in New Zealand seas since the early 1960s. Prions feed by contact dipping, surface seizing, hydroplaning (larger species of prions only) and surface diving. Food includes euphausiids, amphipods, cephalopods, fish and molluscs (Harper *et al.* 1985).

Our information from starved beached birds strongly suggests that prions will eat anything resembling food before they die – the lightest birds had the most pellets. It also shows that adults and immatures ingest pellets equally often when starved. We do not know whether birds in good condition are as easily deceived by plastic pellets.

We also do not know where migrating birds collect plastic pellets. From the observations by Falla (1937) and because the first Indian Ocean migrant prions reach New Zealand in May, we think that the birds take the most direct, wind-assisted route across the subantarctic water zone to New Zealand

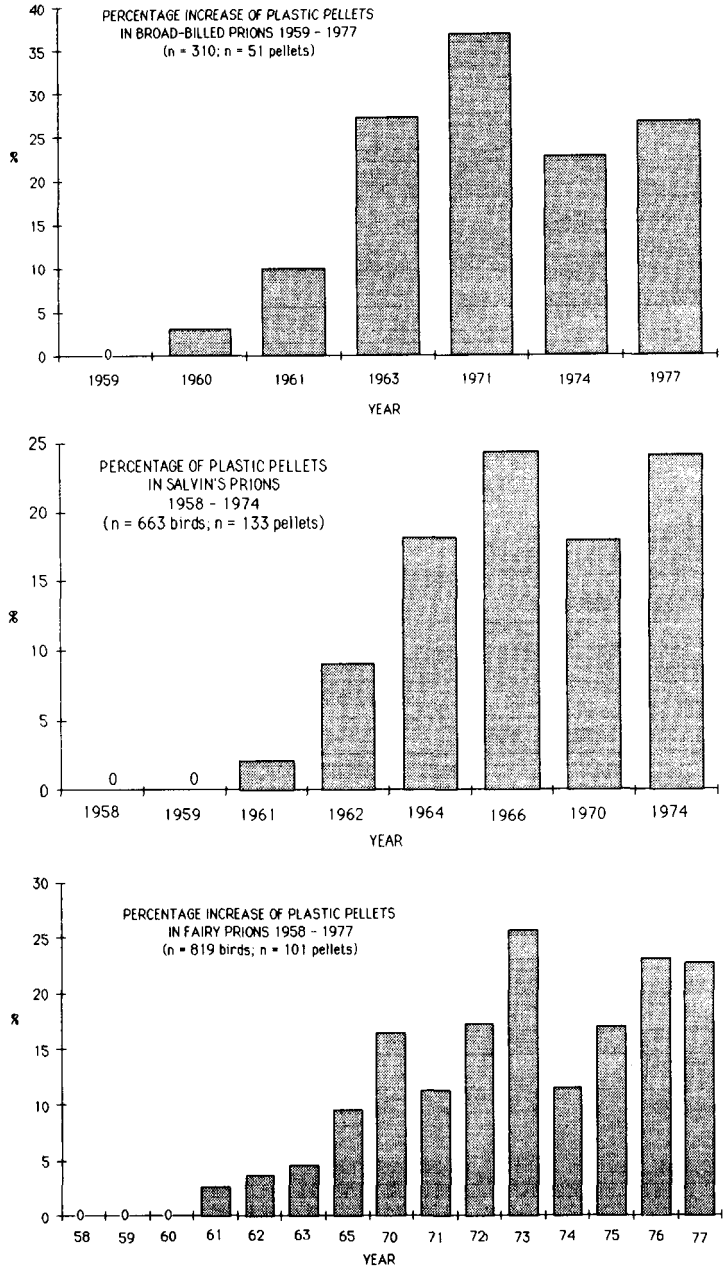
PERCENTAGE INCREASE OF PLASTIC PELLETS
IN BROAD-BILLED PRIONS 1959 - 1977
(n = 310; n = 51 pellets)
%
0
5
10
15
20
25
30
35
40
0
1959
1960
1961
1963
1971
1974
1977
YEAR
PERCENTAGE OF PLASTIC PELLETS
IN SALVIN'S PRIONS
1958 - 1974
(n = 663 birds; n = 133 pellets)
%
0
5
10
15
20
25
0
0
1958
1959
1961
1962
1964
1966
1970
1974
YEAR
PERCENTAGE INCREASE OF PLASTIC PELLETS
IN FAIRY PRIONS 1958 - 1977
(n = 819 birds; n = 101 pellets)
%
0
5
10
15
20
25
30
0
0
0
58
59
60
61
62
63
65
70
71
72
73
74
75
76
77
YEAR

FIGURE 1

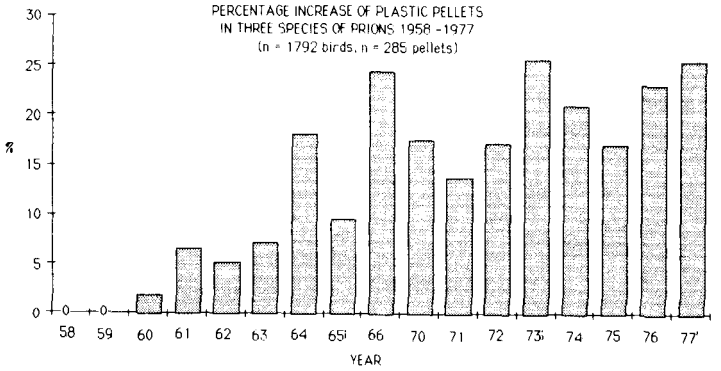

FIGURE 2

TABLE 2 — Relationship between body weight and number of plastic pellets in 79 Salvin's Prions cast ashore in June 1966

Weight in gm	Number of Birds	SEX M	SEX F	Number of Pellets in each Bird
114	1	1		1
112	0			
110	2	1	1	(1)(1)
108	0			
106	2	1	1	(1)(1)
104	0		0	
102	3	2	1	(2)(1)(1)
100	12	6	6	(3)(1)(2)(1)(2)(1)(2)(1)(1)(2)(3)(1)
98	5	3	2	(1)(1)(1)(2)(2)
96	7	5	2	(3)(2)(2)(1)(2)(2)(1)
94	11	6	5	(4)(2)(3)(1)(2)(2)(4)(3)(2)(2)(2)
92	2	1	1	(4)(2)
90	8	5	3	(3)(2)(1)(1)(4)(3)(2)(2)
88	7	4	3	(4)(5)(4)(4)(6)(1)(1)
86	6	0	6	(5)(5)(3)(3)(4)(5)
84	5	4	1	(3)(6)(5)(4)(3)
82	3	1	2	(3)(5)(4)
80	2	0	2	(4)(5)
78	1	0	1	6
76	1	0	1	13
TOTALS	78	41	37	211

– a journey of some 6000 km. They could collect pellets anywhere along this tract of ocean or could take them from convergence or upwelling zones where the pellets might be concentrated.

We also do not know how long plastic pellets remain in the gut of the birds. Because plastic has not been found in the intestinal tract or faeces, Day *et al.* (1985) assumed that the passage of plastic through the intestines does not occur, and yet prions can void intact fish vertebrae the same size as plastic pellets without apparent difficulty (PCH, pers. obs.). Procellariiform birds which feed their young by regurgitation may well regurgitate plastic pellets with squid beaks, but precise information is lacking.

If plastic pellets are passed normally in faeces, the prions in our study would indeed be ingesting pellets in the Australasian region, at a time when the birds' energy reserves were exhausted and shortly before the birds died.

Whether plastic pollution causes damage to seabirds, physically or in their ability to reproduce, is a matter of concern. Our 1966 data showing that the mean body weights of 323 beached Salvin's Prions with and without plastic pellets were similar (p = NS) suggest that the plastic was not primarily responsible for the birds' death. The cause of death was, in this case, probably starvation. Further studies are needed to confirm this finding for the 1980s.

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