THE MINERAL CONTENT OF THE FAECES OF PUKEKO *Porphyrio p. melanotus*

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ABSTRACT

In coastal Manawatu pasture, faecal pellets of the Pukeko (*Porphyrio p. melanotus*) vary in weight through the year and on average disintegrate in about 16 days (range 7-29). The seasonal concentrations of 11 minerals in the faeces are discussed briefly in relation to soil type and the topdressing regime. The addition of faecal minerals to the pasture is estimated per hectare through the year and per bird for autumn. The amounts deposited fall with increasing distance from the edge next to swamp and are largest in autumn when the population is highest.

INTRODUCTION

Pukeko live in lowland swamp but between late summer and mid-winter form conspicuous feeding flocks in adjacent farm land. Although grass and crops may be damaged by such flocks (Guthrie-Smith 1953, Oliver 1955, Carroll 1966, McKenzie 1967) positive effects could be that they induce plant growth, capture insect pests (Oliver 1955), and return minerals to the soil in their faeces.

The mineral content of faeces, however, has not been measured for any indigenous New Zealand bird, except another rail, the Takahe (*Notornis mantelli*), in a single month (Mills *et al.* 1980). The primary aim of this study therefore was to determine the seasonal content of minerals in Pukeko faeces. A secondary aim was to estimate where and in what amounts these minerals are deposited on pasture. The main observations were made at Pukepuke Lagoon (described in Fordham 1983), which supported a Pukeko population that has been intensively studied (Craig 1979, 1980a, 1980b). A second study area at Tiakitahuna (40° 24'S, 175° 30'E) c. 20.3 km east of Pukepuke Lagoon, consisting of crop and pastoral land surrounding a swamp, provided supplementary observations.

METHODS

Between August 1971 and May 1974, I collected 400 faecal pellets from the Hay and Rough paddocks at Pukepuke Lagoon (Fordham 1983, Fig. 1), counting all the faecal matter lying within a circle of 10 cm diameter as one pellet. The freshly voided pellets (of shiny appearance and uneroded shape) were oven dried, ground in a hammer mill for 10 s and sealed individually in polythene sachets. From each of 200 sachets, a subsample of 0.140 g was extracted and the dry matter percentages of nitrogen and phosphorus were determined simultaneously after a modified Kjeldahl digest (Williams & Twine 1967). The contents of 190 sachets were combined by season to make up 18 samples (each of 2.5 g). These were ashed, and the levels of sodium, potassium, magnesium, calcium, aluminium, molybdenum, manganese, iron, and copper were determined by atomic absorption spectrophotometry.

In addition, I collected monthly samples, totalling 1000 fresh faeces, between December 1976 and November 1977 at Pukepuke Lagoon and Tiakitahuna, to estimate the dry weights of pellets. To monitor the rate at which faecal pellets break down physically, 96 fresh faeces were marked with pegs in the Hay paddock, Pukepuke Lagoon, and I inspected them weekly to record their disintegration in the four arbitrary categories of intact, slightly broken, largely broken, and scattered. To measure the distribution of faeces in pasture at Pukepuke Lagoon, I set up in the Hay paddock belt transects 115 m long through eight zones (Fordham 1983), each 12.5 m wide, that were parallel to, and extended a total of 100 m from, the edge of the pasture next to the lagoon. I did the transects once or twice monthly between September 1972 and August 1976 by walking slowly through each zone, counting all faecal pellets in the effective field of view (a central strip c. 3 m wide totalling 0.0345 ha, that is, 24% of each zone).

RESULTS

Weight and mineral content of faeces

The faeces were voided as coherent cylinders c. 8 mm in diameter and c. 60 mm long (maximum > 120 mm) in small piles or curved lines. The pellet diameter was affected by the plant constituents, and pellet length depended on the plant constituents and the bird's walking speed. Table 1 shows the dry weights by season. At Tiakitahuna, the faeces were heavier in spring and summer than in autumn and winter, the extremes being in spring and winter, and the seasonal mean weights differed significantly by t-test ($p < 0.05$). At Pukepuke Lagoon, a low summer population (Fordham 1983) produced few faeces, but the pattern of weights over the other three seasons was the same as at Tiakitahuna, and the seasons differed significantly by t-test ($p < 0.001$).

The seasonal concentrations in faeces of 11 minerals are given in Table 2. The concentrations of both N and P were highest in spring and lowest in autumn, and the differences between the main seasonal levels were significant by t-test ($p < 0.01$). The broad pattern of other elements was of relatively high concentrations in winter, or autumn (Al), and low levels in summer, spring (Na) or autumn (K,Mo). Significant differences (by t-test, p at least <0.05) between seasons of highest and lowest concentrations were obtained for Na, Ca, Al, Mo, Fe and Cu.

TABLE 1 — Seasonal dry weights (g) of fresh faecal pellets collected from pasture at Pukepuke Lagoon and Tiakitahuna, Dec 1976-Nov 1977

	Pukepuke Lagoon			Tiakitahuna		
	n	$\bar{x}$	(±SE)	n	$\bar{x}$	(±SE)
Summer (Dec-Feb)	-			100	0.437	(0.022)
Autumn (Mar-May)	200	0.444	(0.012)	100	0.367	(0.017)
Winter (Jun-Aug)	200	0.338	(0.012)	100	0.319	(0.012)
Spring (Sep-Nov)	200	0.523	(0.020)	100	0.513	(0.029)
Total	-			400	0.409	(0.011)

TABLE 2 — Seasonal concentrations of some minerals in dry matter samples[a] of fresh faeces, Pukepuke Lagoon, 1971-1974

		Na %	K %	Mg %	Ca %	N %	P %	Al µg/g	Mo µg/g	Mn µg/g	Fe µg/g	Cu µg/g
Autumn	$\bar{x}$	0.930	2.258	0.086	1.728	1.937	0.384	1003	0.7	225	7487	5.9
(Mar-May)	±S.E.	(0.258)	(0.327)	(0.008)	(0.208)	(0.071)	(0.017)	(19)	(0.09)	(54)	(678)	(0.55)
Winter	$\bar{x}$	1.000	3.428	0.084	1.953	2.424	0.400	674	1.5	272	11845	8.7
(Jun-Aug)	±S.E.	(0.114)	(0.579)	(0.005)	(0.081)	(0.096)	(0.021)	(99)	(0.16)	(43)	(1555)	(2.28)
Spring	$\bar{x}$	0.705	3.045	0.082	1.470	2.767	0.509	751	1.1	208	8434	3.3
(Sep-Nov)	±S.E.	(0.003)	(0.442)	(0.004)	(0.122)	(0.102)	(0.044)	(108)	(0.34)	(9)	(1057)	(0.55)
Summer	$\bar{x}$	0.896	2.398	0.084	1.194	2.252	0.388	420	0.8	138	2987	2.9
(Dec-Feb)	±S.E.	(0.152)	(0.247)	(0.004)	(0.229)	(0.104)	(0.020)	(85)	(0.02)	(44)	(498)	(0.61)
Year	$\bar{x}$	0.886	2.732	0.084	1.572	2.345	0.414	712	1.0	207	7416	5.1
	±S.E.	(0.084)	(0.212)	(0.003)	(0.109)	(0.051)	(0.015)	(63)	(0.11)	(22)	(881)	(0.75)

[a] Except for N and P faeces were combined seasonally into 2.5 g samples: autumn (n = 5, 45 faeces); winter (n = 4 49 faeces); spring (n = 4, 51 faeces); summer (n = 5, 45 faeces). For N and P the sample for each season = 50 separate faecal pellets.

Distribution and disintegration of faeces

Faecal counts from 68 transects were pooled for each zone to provide an index of faecal distribution in the Hay paddock in 1972-1976. Faeces declined in frequency outwards from the pasture edge with 59.9% (n = 1663) dropped in the first two zones (0-25 m from the edge). Only 15.7% of faeces were dropped beyond zone 4 (>50 m from the edge) and 3.1% beyond zone 6 (>75 m from the edge). Because Pukeko began to use the neighbouring Rough paddock after 1972, progressively fewer faeces were left in the Hay paddock. But although fewer were dropped than between September 1971 and August 1972, when I had made weekly transects only through zones 1-4, the overall distributional gradient was generally consistent in each year and season. Between 1972 and 1976, the mean densities per hectare of faeces in zones 1-8 of the Hay paddock were respectively 272, 153, 92, 81, 40, 50, 10 and 12; overall mean for all zones, 89. During autumn (March-May), when the population was at its annual peak (Fordham 1983), the mean density of faeces for zones 1-2 alone was 496/ha and for all eight zones 217/ha.

The maximum time taken for freshly voided pellets to disintegrate and become no longer recognisable was 15.7 ± 0.73 days (range 7-29 days). Breakdown took longer in winter (18.2 ± 1.49, n = 30) and spring (17.3 ± 1.08, n = 36) than in summer (7.6 ± 0.62, n = 8) and autumn (12.8 ± 0.95, n = 22). Apart from winter and spring, which were not different by t-test, seasonal means were all significantly different ($p < 0.001$).

Deposition of minerals on the pasture

Table 3 shows the mean deposition (g/ha) of minerals in the Hay paddock, Pukepuke Lagoon, through each season, based on the mean faecal weights and content and the density of faeces in different zones of the pasture. For the table, the mean dry weight of summer faeces was estimated to be 0.484 g (the mean of the spring and autumn values) because at Tiakitahuna summer faeces weighed, on average, only 0.003 g (0.682%) less than the mean of the spring and autumn weights (Table 1). The seasonal pattern of minerals for zones 1-2 and for all 8 zones comprised a peak in autumn followed by a low in spring, and a summer value estimated at higher than those in winter or spring. On average K, Ca, and N were present in amounts > 1 g/ha; Na, P and Fe in amounts between 0.1 and 1 g/ha; Mg, A1, and Mn in amounts between 0.001 and 0.1 g/ha; and Mo and Cu only as traces < 0.001 g/ha.

To estimate the contribution per bird to the minerals of the pasture for one season (autumn), I used the data in Tables 1 & 2 and observations of the rate of defecation. The average daily rate of defecation by two captive Pukeko kept for 6 days on pasture in April 1972 was 48.7 pellets (range 42-58), equivalent to c. 2.9 m of faeces per bird. Allowing for age and sex differences in body weight and the age and sex composition of the Pukepuke Lagoon flock (Craig 1974), a flock of 50 birds in the autumn peak population would constitute a biomass of c. 46 kg of Pukeko dispersing daily between swamp and pasture. The total amount of minerals defecated by such a flock for the 92 days of autumn (March-May) could be in the order of Na 925 g, K 2245 g, Mg 86 g, Ca 720 g, N 1927 g, P 382 g, Al 100 g, Mo 0.07 g, Mn 22 g, Fe 745 g, and Cu 0.059 g. Some of this load, of course, would fall in the adjacent swamp, not on the pasture, but the amount of faecal deposition in the swamp has not been measured.

DISCUSSION

The concentrations of minerals in Pukeko faeces result partly from the stocks of minerals in the plants they eat and in the water and soil (Kear 1963, Wilkinson & Lowrey 1973) and partly from the birds' metabolism. At Pukepuke Lagoon the sandy soils are imperfectly drained, and free water may lie on the surface in winter and spring. The soils are low in clay and organic matter, slightly acid, and high in Ca and N, medium in P, and very low in K. Copper, Co, and Se may be deficient (Cowie *et al.* 1967). The high concentrations of K, Ca, and P in the faeces were undoubtedly influenced by the fertiliser potassic-superphosphate (15% potassium chloride and 85% calcium hydrogen phosphate and calcium sulphate). This fertiliser was applied at the rate of 250 kg/ha to the Hay paddock in November to promote hay growth through late spring and summer and at the rate of 188 kg/ha to the Rough paddock in March or April to boost spring pastures. Trace elements were not applied, although lambs were dosed directly with selenium (P. Barber, pers. comm.). The relatively high concentration of Na in faeces was probably the result of spray from the sea (3.2 km to the west) being continually received by swamp and pasture plants. The pattern of high winter and low summer concentrations in the faeces of minerals such as Mn, Fe and Cu may reflect relatively more ingestion by the birds of soil in winter, as occurs in domestic stock (M.A.

TABLE 3 — Estimates of the mean seasonal deposition (g/ha) of some minerals present in pukeko faecal pellets in the Hay paddock bordering Pukepuke Lagoon, 1972-1974
t (trace) < 0.001 g/ha

	Distance (m) from pasture edge	*Na*	*K*	*Mg*	*Ca*	*N*	*P*	Al	Mo	Mn	Fe	Cu
Autumn	0-25	2.048	4.972	0.189	3.805	4.266	0.846	0.221	t	0.050	1.649	0.001
(Mar-May)	0-100	0.896	2.176	0.083	1.665	1.866	0.370	0.097	t	0.022	0.721	t
Winter	0-25	0.352	1.205	0.030	0.687	0.852	0.141	0.024	t	0.010	0.416	t
(Jun-Aug)	0-100	0.105	0.359	0.009	0.205	0.254	0.042	0.007	t	0.003	0.124	t
Spring	0-25	0.118	0.510	0.014	0.246	0.299	0.085	0.013	t	0.003	0.141	t
(Sep-Nov)	0-100	0.074	0.319	0.009	0.154	0.289	0.053	0.008	t	0.002	0.088	t
Summer	0-25	0.807	2.159	0.076	1.075	2.027	0.349	0.038	t	0.012	0.269	t
(Dec-Feb)	0-100	0.312	0.836	0.029	0.417	0.785	0.135	0.015	t	0.005	0.104	t
Annual	0-25	0.840	2.589	0.080	1.490	2.222	0.392	0.067	t	0.020	0.703	t
Mean	0-100	0.352	1.087	0.033	0.625	0.933	0.165	0.028	t	0.008	0.295	t

Turner, pers. comm.), through particles splashed on to plants or swallowed directly. Compared with Takahe faeces in late winter (Mills *et al.* 1980), the concentration of Mg in Pukeko winter faeces was low but the levels of Na, K, Ca, N and P were much higher.

There is no other work on the faecal minerals of any indigenous New Zealand bird with which to compare the present results. The study by Stewart *et al.* (1974) of Pukeko near the Tiwai Point aluminium smelter concerned only the level of fluorine in bones and other tissues.

The distribution and density of faeces in the pastures broadly reflected that of the birds (Fordham 1983), except that the birds were scored more often next to the swamp because in zone 1 of the pasture they mostly used a 2 m strip along the edge, whereas the standard transect for counting faeces was centred 7 m from the edge. Therefore the numbers of faeces in zone 1 was underestimated.

The disintegration of faeces did not appear, from direct evidence, to be influenced strongly by stock numbers or water levels.

The estimates of minerals deposited per hectare on pasture are conservative because the transects underemphasised faecal density in zone 1. The estimates were influenced mainly by seasonal changes in faecal (i.e. bird) numbers, the seasonal variation in size and content of faeces having comparatively little effect. The estimates of minerals contributed by a flock of 50 birds in autumn are likely to be maxima, however, because the captives may have had a higher rate of defecation than they would when feeding on a natural mixed diet of swamp and pasture plants. Reid (1974) found that captive Takahe voided more faeces (about 8 m/day) on a less nutritious diet of grass or tussock than on a more nutritious one of poultry pellets and grass. Pukeko vary their use of habitats and their diet with the season (Wright 1978, Fordham 1983), and so their rate of defecation in autumn is not likely to be the same in other seasons.

The conclusion is that, although Pukeko are one of the main vertebrate agents of mineral interchange between the swamp and adjoining pasture at Pukepuke Lagoon, their faeces are short-lived and contribute little to the overall mineral supply of the pasture.

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SHORT NOTE

An Oystercatcher in Vanuatu

I was visiting Vanuatu on 29 September 1983, doing conservation work on behalf of the South Pacific Regional Environment Programme and the International Council for Bird Preservation, when I was surprised to observe an oystercatcher, a bird not previously recorded for that country.

On the waterfront at Vila, I noticed the characteristic piping calls and saw the bird circling low overhead before it landed on the grassed area by the sea wall opposite the Post Office. It remained on the ground long enough for me to examine it with 8x30 binoculars from about 50 metres before it flew again. The pattern of black and white, both on the ground and in the air, was indistinguishable from that of the South Island Pied Oystercatcher (*Haematopus ostralegus finschi*). The white of the breast ended in a sharp line forward of the wing flexure, the lower two-thirds of the back was white and the white wing-bar was prominent. Bill and leg colour appeared to be slightly paler than the deep orange expected on an adult bird, but this feature is difficult to assess on a lone bird.

Appearing particularly agitated, the oystercatcher circled several times and settled very briefly on the flat roof of one of the waterfront buildings before flying across the harbour towards Iririki Island. It was attracting some interest from local people, and those that I spoke to said that they had never seen a "pijin" like that there before.

The origin of this bird is debatable, the two most likely sources being New Zealand and Australia. The Australian Pied Oystercatcher (*H. ostralegus longirostris*) is distributed over much of the coast of that country but is quite sedentary, has a smaller population than the New Zealand subspecies and is found mainly in the southeast (Blakers *et al.* 1984). Moreover, it does not have as much white on the back as was seen on this bird (A. E. Baker, pers. comm.). This feature leads to the conclusion that it was a South Island Pied Oystercatcher.