SHORT NOTE

The diet of Kakapo (*Strigops habroptilus*), Takahe (*Porphyrio mantelli*) and Pukeko (*P. porphyrio melanotus*) studied by faecal analysis

Faecal analysis is a useful method for investigating the diet of animal species, especially when the animals are scarce or elusive. The major problem with the technique is the difficulty of relating faecal components to quantities of various foods eaten (Storr 1961, Fitzgerald 1976, Fitzgerald & Waddington 1979). I present the results of two studies that used faecal analysis to examine aspects of the diets of translocated Kakapo (*Strigops habroptilus*) and Takahe (*Porphyrio mantelli*) in offshore island habitats. In each case a comparison is made using only incidence data, the proportion of droppings that contained the remains of a particular food type. This approach gives a conservative but rigorous estimation of the overall diet.

The food of adult and chick Kakapo on Little Barrier and Codfish Islands

Faecal material examined was collected by Department of Conservation workers, myself and other volunteers from Kakapo translocated to Little Barrier Island. The sample consisted of 204 droppings from adults collected between 12 March 1990 and 3 April 1991, and 32 droppings from chicks (in two nests) collected between 2 March 1991 (just after hatching) and 8 April 1991. Following examination with a binocular microscope to remove large objects such as stones and seeds (*Coprosma, Astelia*) whole droppings were macerated in water and homogenised with an electric blender (Fitzgerald & Waddington 1979). After staining with basic fuchsin and thorough agitation, a subsample was taken from each processed dropping using a 5 mm bore glass tube and placed on a glass slide that had previously been etched across its width with several transect lines. Slides were systematically surveyed by scanning along transect lines and identifying tissue particles that overlay them. Approximately 100 food tissue fragments were identified from each dropping and I have used these data to calculate incidence values for the occurrence of each food type. This was done by dividing the number of droppings in which a particular food type was observed by the total number of droppings examined and multiplying by 100. The results are presented in the form of a bar chart with food categories ordered according to their incidence-ranking in adult droppings (Figure 1). For each food category three frequencies are shown, corresponding to the incidence of that food in: (a) the 204 adult droppings collected during 12 March 1990 - 2 April 1991, (b) 23 adult droppings found during 2 March - 8 April 1991 (the period when chick droppings were collected) and (c) 32 droppings from chicks.

The composition of the droppings indicated that adult Kakapo ate a wide range of plant species, mostly leaves (Best 1984). No remains of animals were found in any droppings. The data demonstrate that Kakapo chicks are not fed animal foods even during their first weeks of life, and this is atypical. Most large, herbivorous, terrestrial birds, such as grouse (Tetraonidae) make extensive use of invertebrates during the equivalent period; conversely other large New Zealand parrots use animal foods throughout life. Kakapo on Little Barrier Island use food

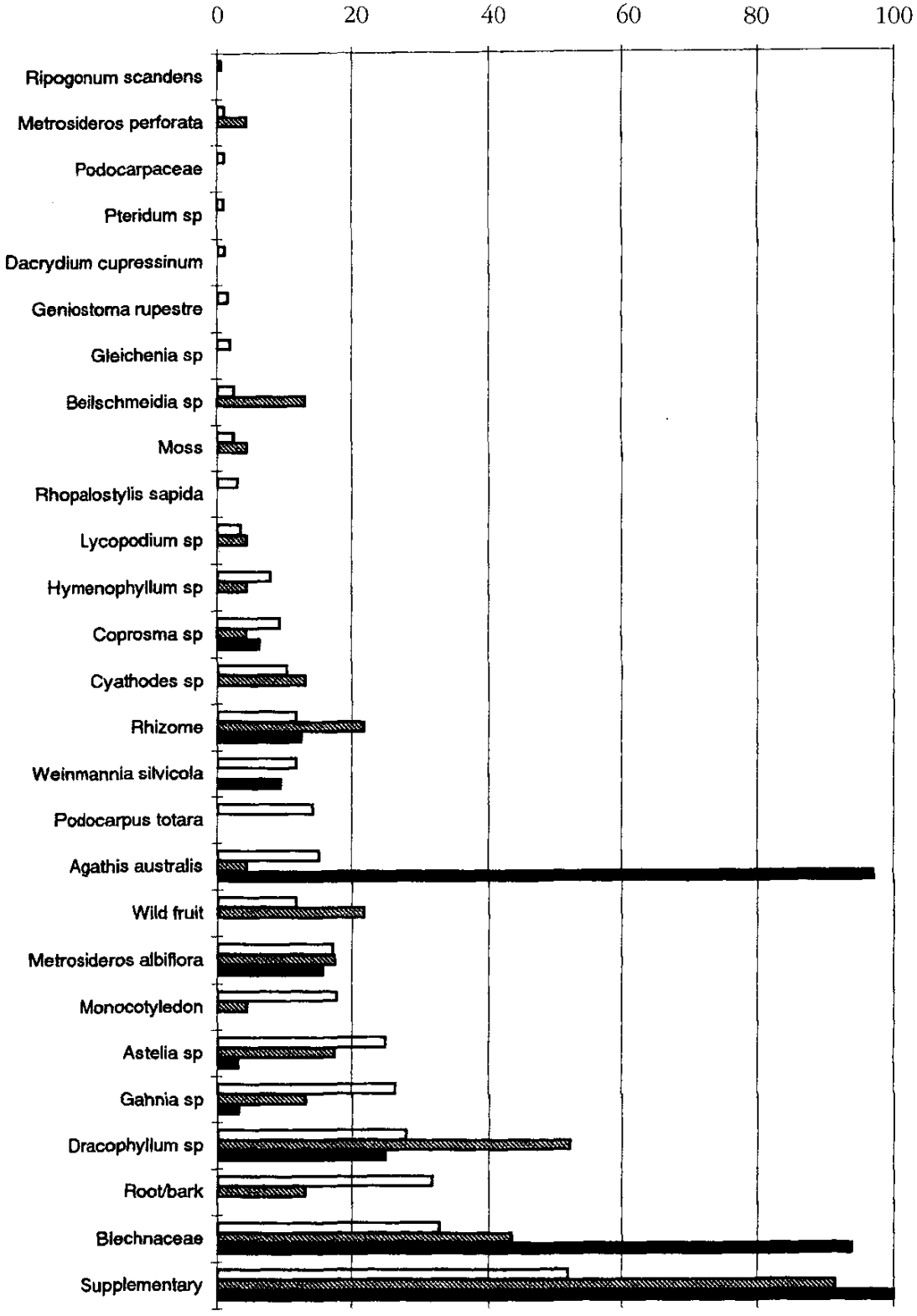

FIGURE 1 - Percent occurrence of various plant species tissues in the droppings of Kakapo on Little Barrier Island collected between 12 March 1990 and 3 April 1991. The categories are ordered from least to most frequent (left to right) and numbered 1 to 27. For each category frequency data is given for: (a) all adult droppings (N=204) (open bars), (b) adult droppings collected during the same period as chick droppings (N=23) (shaded bars), and, (c) chick droppings (N=32) (black bars). In each category, remnants of leaves were encountered unless otherwise stated, eg. "rhizome" refers to fern rhizomes. "Supplementary" refers to food remnants derived from seven types of nuts and fruit provided by the supplementary feeding program.

provided in a supplementary feeding program run by the Department of Conservation (Powlesland & Lloyd 1994). This food source was particularly important for Kakapo chicks and adults during the breeding period, as indicated by the high incidence of "supplementary" in the adult droppings collected during chick rearing (Fig. 1 b). Of the natural foods, *Blechnum* fern frond was the major dietary component overall (Fig. 1), confirming observations from other studies (Gray 1977, Best 1984, Moorhouse 1985). *Dracophyllum, Gahnia* and *Astelia* were present in 20-30% of adult droppings (Fig. 1; a), whilst other components were found in fewer than 20% of the same sample of droppings. Many food components occurred with extremely low incidence and this may reflect local variation in nutritive quality of potential food plants and/or individual preference amongst Kakapo.

Kauri (*Agathis australis*) leaves were a major component in the diet of chicks reared on Little Barrier Island in 1990/91. Kauri occurred in almost as many droppings from chicks as supplementary food did (98% vs. 100%, respectively), but in only few (<15%) adult droppings.

One explanation for the apparent high incidence of kauri in Kakapo chick droppings could be derived from the fact that Kakapo chicks feed exclusively on partially digested food regurgitated from the crop of the female parent. As kauri leaves contain tough structures that are resistant to digestion it is plausible that kauri remains maybe over-represented in chick droppings as a result of the relatively greater digestion of softer food items. However, food consumed by chicks is probably processed little more than once if it is masticated and stored in the crop of the adult and then passes rapidly into the gut of the chick following regurgitation. Futhermore, the use of incidence data makes it extremely unlikely that if kauri were present in more adult droppings it would have failed to contribute to the incidence value. The consistent incidence of other food components such as white rata (*Metrosideros albiflora*), in the droppings of adults and chicks lends support to this argument.

Five droppings collected from two nests containing Kakapo chicks in April 1992 on Codfish Island contained the remains of fruits and leaves of rimu (*Dacrydium cupressinum*) and no other plant species (Trewick, unpubl.). This agreed with field observations that female Kakapo with chicks spent most of their foraging time in rimu trees (R. Buckingham, pers. comm.) and suggests that female Kakapo are prepared to feed chicks on a single food type if abundant and of suitable quality. On Little Barrier Island, the frequent occurrence of kauri fragments in chick droppings suggests that females with chicks may have sought nutrients available in kauri leaves that supplementary food did not provide.

Takahe and Pukeko diet on Kapiti and Mana Islands

Fresh droppings of translocated free ranging Takahe (N=188) and wild Pukeko (*Porphyrio porphyrio melanotus*) (N=93) were collected during six trips to Mana and Kapiti Islands between December 1992 and February 1993. Droppings from both species were collected in the same pasture grassland and swamp habitats, with a similar number collected on each visit. Each dropping was macerated in water and then examined under a binocular microscope, the food fragments (which are very

large) being assigned to the nine broad food-type categories given in Table 1. These categories were based on field observations of feeding Takahe and Pukeko. The presence of the food remnants in droppings was transformed into incidence data, as above.

On Mana Island, where much of the sward is dominated by course prairie grass (*Bromus unioloides*) the seeds of this plant were apparently the dominant food of Pukeko (68.3%) and Takahe (72.5%) during the sample period. On Kapiti Island, the grass in the areas used by Pukeko and Takahe, includes smaller seeded species (e.g. *Poa* sp.). Here, the tillers of these soft grasses were the dominant component of both Pukeko (66.7%) and Takahe (61.1%) droppings. The remains of leaves and runners of clover (*Trifolium* spp.) were also a frequent component of Pukeko and Takahe droppings from both islands, and this concurs with feeding observations of these species. Observations of native New Zealand Pigeon (*Hemiphaga novaeseelandiae*) on Kapiti, as well as gut analysis of Feral Turkey (*Meleagris gallapavo*) (Schemnitz 1992) and Tasmanian Native Hen (*Tribonyx mortieri*) (Ridpath 1972), show that clover is an attractive food source for many bird species, despite it being an introduced plant.

Pukeko droppings from Mana contained a high incidence (52.4%) of animal components (Table 1). Of the 33 droppings that contained animal components seven included the remains of Giant Weta (*Deinacrida rugosa*) which are very abundant on Mana (McIntyre 1992). In contrast, Takahe fed rarely if at all on weta, despite foraging in the same areas as Pukeko (Table 1). Field observations (pers. obs., G. Climo pers. comm., Dawson 1994) all show that Takahe do occasionally feed on invertebrates. On Kapiti Island (pers. obs.) and in Fiordland (Falla 1951)

TABLE 1 - Percent occurrence of nine food categories in droppings of Pukeko and Takahe on Mana and Kapiti Islands collected between December 1992 and February 1993. 'Dicotyledonous leaf' category is mostly clover leaf but includes the leaves of other herbs. Coarse and fine grass seed were mainly *Bromus unioloides* and *B. diandrus* in the first instance, and *Poa pratensis* and *Holcus lanatus* in the latter. Animal remains included hard parts of beetles, moths and weta. Sample sizes: Pukeko, Mana I. N=63, Kapiti I., N=30; Takahe, Mana I., N=80, Kapiti I., N=108.

Food category	Pukeko			Takahe		
	Mana I.	Kapiti I.	Both	Mana I.	Kapiti I.	Both
Tiller	17.5	66.7	33.3	28.8	61.1	47.3
Grass leaf	15.9	16.7	16.1	28.8	13.0	19.7
Grass seed, fine	22.2	40.0	28.0	31.5	42.6	37.8
Grass seed, fine	68.3	36.7	58.1	72.5	24.1	44.7
Clover runner	36.5	3.3	25.8	18.8	16.7	17.6
Dicotyledonous leaf	12.7	3.3	9.7	36.3	20.4	27.1
Poroporo seed	7.9	0	5.4	0	0	0
Sedge seed	1.6	0	1.1	2.5	13.9	9.0
Animal remains	52.4	50.0	51.6	1.3	17.6	10.6

adult Takahe have been observed using a sward-pulling method to forage for invertebrates to feed to chicks, but the adults have not been seen to eat the animals found themselves.

I grouped the data by island and by consumer so that a total of six groups were produced (Table 1), and used a Spearman rank correlation coefficient to make a pairwise comparison of the rankings of food incidence in each. Takahe on Mana vs Pukeko on Mana was the only comparison showing significant differences. The principle reasons for this were probably the presence of poroporo (*Solanum laciniatum*) seeds and animal components in Pukeko droppings from Mana.

The range of foods used by Pukeko and Takahe on Mana and Kapiti Islands during December 1992 - February 1993 were similar, with the exception of poroporo seeds which occurred in just five Pukeko droppings (8%) from Mana. Takahe and Pukeko diet appear similar on each island, and is greater than the variation for each species between the islands. This suggests that both Takahe and Pukeko may be responding to local food availability rather than to innate food preferences.

Although the sample sizes are relatively small and only cover part of one year, the results indicated strong similarity between the diets of Pukeko and Takahe, and this agrees with field observations (Bunin 1995). The food eaten on the islands seems to be influenced by both availability (e.g. dominance of prairie grass on Mana), and quality (as indicated by apparent selection of clover). It seems reasonable to suggest that Takahe in Fiordland respond to that environment in the same way as those on islands, choosing the best of what is available rather than being specifically adapted to subalpine vegetation as proposed by Mills et al. (1984, 1991).

ACKNOWLEDGEMENTS

I thank Ralph Powlesland, Bill Lee and an anonymous reviewer for comments on the manuscript, Ralph Powlesland, Don Merton, other Department of Conservation workers and volunteers for collecting droppings, Terry Greene for providing plant reference material as well as Phill Todd, Trevor Hook, Peter Daniel, Raewyn Empson, Gideon Climo, Rhys Buckingham.

LITERATURE CITED

BEST, H. A. 1984. The foods of the kakapo on Stewart Island as determined by their feeding sign. N. Z. J. Ecol. 7: 71-83.

BUNIN, J. S. 1995. Preliminary observation of behavioural interactions between Takahe (*Porphyrio mantelli*) and Pukeko (*P. porphyrio*) on Mana Island. Notornis 42: 140-143.

DAWSON, N. 1994. The behavioural ecology and management of the Takahe. Unpublished MPhil Thesis. University of Auckland, New Zealand.

FALLA, R. A. 1951. The nesting of Notornis. Notornis 4: 97-101.

FITZGERALD, A. E. 1976. Diet of opossum *Trichosurus vulpecula* (Kerr) in the Orongorongo Valley, Wellington, New Zealand, in relation to food-plant availability. N. Z. J. Zool. 3: 399-419.

FITZGERALD, A. E.; WADDINGTON, D. C. 1979. Comparison of two methods of fecal analysis of herbivore diet. J. Wildl. Manage. 43: 468-473.

GRAY, R. S. 1977. The kakapo. Its food, feeding and habitat preferences in Fiordland and Maud Island. Unpublished MSc Thesis. Massey University, Palmerston North, New Zealand.

MCINTYRE, M. E. 1992. Dispersal and preliminary population estimates of the giant weta (*Deinacrida rugosa*), following eradication of mice from Mana Island. Unpublished report to the Department of Conservation, Wellington.

MILLS, J. A.; LAVERS, R. B.; LEE, W. G. 1984. The Takahe- A relict of the Pleistocene grassland avifauna of New Zealand. N. Z. J. Ecol. 7: 57-70.

MILLS, J. A.; LAVERS, R. B.; LEE, W. G.; MARA, M. K. 1991. Food selection of Takahe (*Notornis mantelli*) in relation to chemical composition. Ornis Scand. 22: 111-128.

MOORHOUSE, R. J. 1985. Some aspects of the ecology of kakapo (*Strigops habroptilus*) liberated on Little Barrier Island (Hauturu). Unpublished MSc Thesis, University of Auckland, New Zealand.

POWLESLAND, R. G.; LLOYD, B. D. 1994. Use of supplementary feeding to induce breeding in free-living Kakapo *Strigops habroptilus* in New Zealand. Biol. Cons. 69: 97-106.

RIDPATH, M. G. 1972. The Tasmanian native hen, *Tribonyx mortierii*. III Ecology. CSIRO Wildl. Res. 17: 91-118.

SCHEMNITZ, S. D. 1992. Weights, measurements and autumn foods of free-ranging turkeys in New Zealand. Notornis 39: 126-129.

STORR, G. M. 1961. Microscopic analysis of faeces, a technique for ascertaining the diet of herbivorous mammals. Aus. J. Biol. Sci. 14: 157-164.

STEVE TREWICK, *School of Biological Science, Victoria University of Wellington, P. O. Box 600, Wellington, New Zealand. Current address: School of Biological Science, Macquarie University, Sydney, N.S.W. 2109, Australia*

Received 28 October 1995

Revised and accepted 31 January 1996