

The diet of New Zealand falcons (*Falco novaeseelandiae*) on the Auckland Islands, New Zealand

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Abstract Prey remains and regurgitated pellets of New Zealand falcons *Falco novaeseelandiae*, from Adams I in the Auckland Is, were collected to determine the diet of this species in the subantarctic part of their range. Dissection of pellets revealed 1588 bones from 215 individuals of 18 species of birds preyed upon. Feathers associated with the remains supported the bone identifications. Rangle stones were also collected. The presence of procellariiform seabirds in the diet of falcons suggests some nocturnal hunting. While the single most frequent prey species was the bellbird (*Anthornis melanura*), Antarctic prion (*Pachyptila desolata*) and subantarctic diving petrel (*Pelecanoides urinatrix exsul*) were also common. When measured by prey weight, endemic land birds such as Auckland I rail (*Lewinia muelleri*), Auckland I snipe (*Coenocorypha aucklandica aucklandica*), and Auckland I teal (*Anas aucklandica*) constituted a third of the prey. Like many island birds, these ground-dwelling species cannot co-exist with introduced mammalian predators, but survive despite predation by native falcons.

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Keywords New Zealand falcon; *Falco novaeseelandiae*; Auckland Islands; diet; prey remains; seabirds; rangle stones

INTRODUCTION

The Auckland Is (50° 45' S, 166° 10' E) lie in subantarctic waters in the South Pacific Ocean, approximately 460 km south of the South I of New Zealand. They include 3 main islands of which the largest is Auckland I, with Enderby I to its north and Adams I to its south. Numerous smaller islands, islets and stacks, contribute to a total area of 62,564 ha. The islands have a rich avifauna with at least 46 species of breeding birds, including several endemic taxa: Auckland I teal (*Anas aucklandica*), Auckland I rail (*Lewinia muelleri*), Auckland I dotterel (*Charadrius bicinctus exilis*), Auckland I snipe (*Coenocorypha a. aucklandica*), Auckland I pipit (*Anthus novaeseelandiae aucklandicus*), and Auckland I tomtit (*Petroica macrocephala marrineri*; Clark & Dingwall 1985).

The islands are also home to a population of New Zealand falcon (*Falco novaeseelandiae*).

Compared to populations on the New Zealand mainland, falcons on the Auckland Is live in a harsh maritime environment. Little information exists on the status or biology of the Auckland I population of New Zealand falcons. They were discovered in 1839 by Hombron and Jacquinot, aboard a French expedition (Oliver 1955), and specimens were collected in 1840 by the British expedition in the *Erebus* and *Terror* (Oliver 1955). Ten specimens collected in the 1940's, which are now deposited at the Museum of New Zealand, Te Papa, had some details of stomach contents noted, indicating that prion species and white headed petrel (*Pterodroma lessoni*) had been preyed upon. More recently, Yaldwyn (1975) noted that falcons in the Auckland Is appeared to be feeding mainly on Antarctic prion (*Pachyptila desolata*). One bird was seen to

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Fig. 1. View of Maclaren Bay, Adams I, Auckland Is. Arrow shows approximate location of New Zealand falcon nest.

take a pipit and another observed hunting mice. Chance (1992) also reported numerous falcon-killed Antarctic prions littering the forest floor. In 1989, the New Zealand Department of Conservation located 5 nests, and estimated the Adams I population totalled only approximately 15 birds.

On mainland New Zealand, falcons eat a wide variety of prey but their diet chiefly consists of birds, introduced mammals and insects (Barea 1995; Fitzgerald 1965; Fox 1977; Lawrence & Gay 1991; Marchant & Higgins 1993; Stewart & Hyde 2004; Seaton *et al.* 2008). Apart from direct observations of prey capture, the diet of falcons can be studied by analysis of prey remains and regurgitated pellets (Fox 1977). Marchant & Higgins (1993) reported that pellets from falcons in northeast South I included many species of insects, birds (mainly passerines), and mammals such as rabbits (*Oryctolagus cuniculus*), hares (*Lepus europaeus*) and small rodent species. However, falcons have been known to take birds as large as pheasant (*Phasianus colchicus*; Hyde & Seaton 2008), weka (*Gallirallus australis*), kaka (*Nestor meridionalis*), and white-faced heron (*Ardea novaehollandiae*; Marchant & Higgins 1993).

Worthy (1997), Worthy & Holdaway (1995), and Worthy *et al.* (2002) reported that the prey remains of falcons from fossil deposits were dominated by diurnal species, with skinks (*Oligosoma* spp), quail (*Coturnix novaehollandiae*), and parakeets

(*Cyanoramphus* spp) the favoured prey, and rodents very common after their introduction. However, in the Te Waka #1 site, near Te Pohue inland Hawkes Bay, petrels were the primary prey, with Cook's petrel (*Pterodroma cookii*) and mottled petrel (*P. inexpectata*) the most frequent species (Worthy *et al.* 2002). Similarly, petrels dominated the diet of falcons in the Kowhai Valley, Seaward Kaikoura Mts, below the Hutton's shearwater (*Puffinus huttoni*) colony (Harrow 1976).

As little is known of falcons on the Auckland Is, we analysed regurgitated pellets and prey remains to determine the extent to which petrels and native land birds feature in the diet of falcons in this harsh maritime environment. Here, we describe the avian composition of the diet of New Zealand falcons on the Auckland Is.

METHODS

The diet of New Zealand falcons was studied between 1-11 Nov 1993 during a 2½ day visit to Maclaren Bay, Adams I (Fig. 1), where on previous expeditions by the Department of Conservation, falcons had been noted to nest. A search found 1 pair using the area in Nov 1993. The nest containing 2 eggs was located by following the direction of the male falcon, as he flew overhead and then following the sound of the female whining to the male within the rata forest. The birds were observed from sufficient distance so

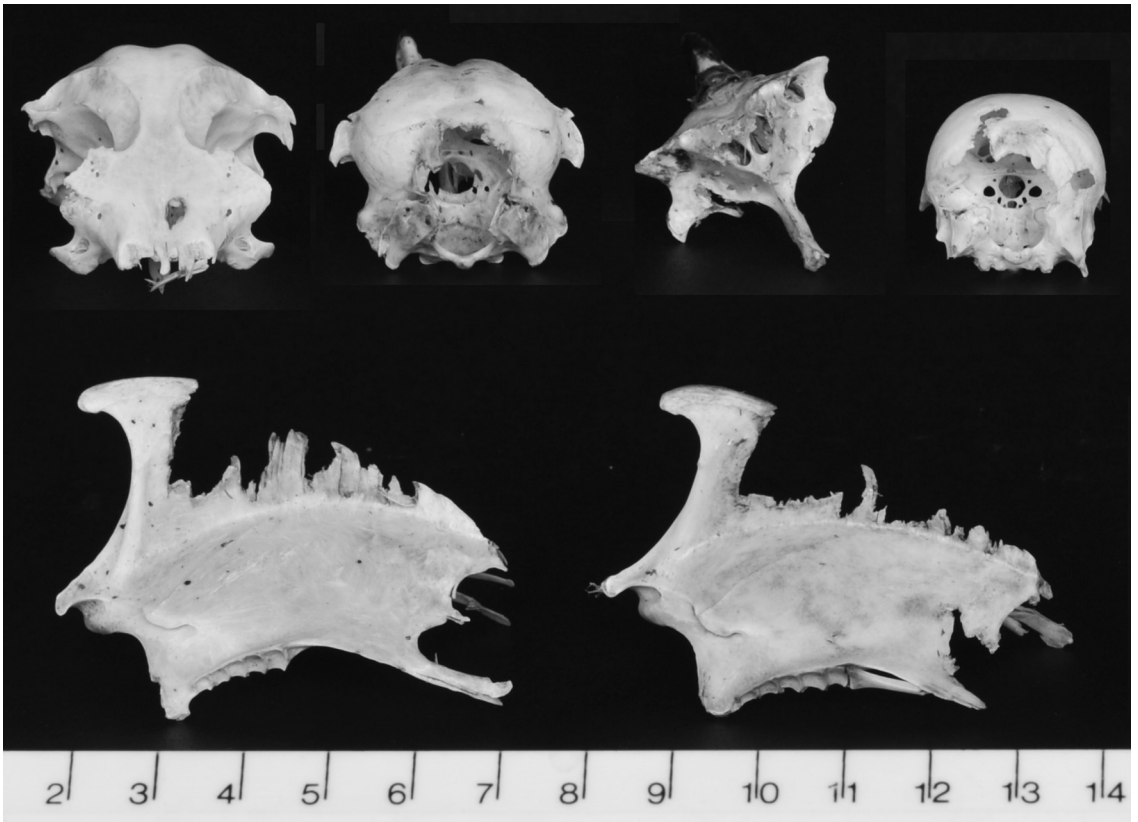


Fig. 2. Prey remains of falcons from Adam I, Auckland Is. Top row, left to right: front of skull of white headed petrel (bill missing) showing falcon beak puncture mark; sooty shearwater, showing back of skull bitten out; white headed petrel, entire crania and back of skull removed; Auckland Island teal, back of skull eaten out. Bottom row: white headed petrel sterne showing bite marks characteristic of falcon predation. Scale bar in cm.

as to not disturb them while their favoured perches were determined. Then a thorough search was made below these perches during each of 5 visits to collect uneaten prey remains and pellets. Pellets and prey remains were put into separate containers and labelled to avoid mixing.

The prey remains of falcons consist of uneaten prey and regurgitated pellets. The uneaten prey comprised usually the wings, legs, head and feathers. They are recognised as prey remains of falcons by the fact that they are found at known roosts, feeding posts or at the nest site, and usually have characteristic damage patterns (Fox 1977). For example, the wings are usually entire distal to the humerus. Often the paired wings remain as part of a unit connected by the defleshed pectoral girdle elements (furcula, scapulae, coracoids and sternum). The sternum often has characteristic damage in the form of notches along and towards the front of the carina. If skulls are present, they often have a characteristic feeding-damage pattern, where the back of the crania is missing and occasional beak

puncture marks are present (Fig. 2). The neck vertebrae immediately behind the skull can often show signs of being bitten or crushed (*pers. obs.*). Regurgitated pellets are oval in shape and consist of undigested keratinous material such as beaks, claws, feet, and feathers, and bone fragments.

The pair of falcons roosted on 2 rata trees (*Metrosideros umbellata*) immediately in front of their nest, from which they had a view of the surrounding area and from which they usually entered and exited the nest area. Two large horizontal rata trunks were used as plucking posts and mounds of sphagnum moss on the forest floor were used for both plucking and feeding. It was relatively easy to examine these favoured and other likely areas for both pellets and prey remains. No samples were found or collected from in the immediate nest area.

Loose feathers from prey remains were collected on and around falcon plucking posts, and were easily detected against the green sphagnum moss, which covered large areas of the forest floor. Whole and partial wings were collected from these areas

| Taxon | FBL | | FBY | | MB | | MB93 | | SB | | SCB | | SCB | | A190 | | A190 | | FB | | SBMW | | Total | |
|--------------------------------------|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|-------|-----|
| | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI |
| <i>Pelecanoides</i> sp. | 1 | 1 | 1 | 1 | 87 | 8 | 34 | 5 | | | | | | | 13 | 5 | | | | | | | 135 | 19 |
| <i>Pachyptila</i> sp. | 13 | 1 | 41 | 8 | 5 | 1 | 17 | 2 | 109 | 8 | 5 | 1 | | | | | | | | | | | 190 | 21 |
| cf <i>Pachyptila</i> | 1 | 1 | | | | | | | | | | | | | | | | | | | | | 1 | 1 |
| <i>Pelagodroma marina</i> | 6 | 1 | | | | | | | | | | | | | | | 68 | 4 | | | | | 74 | 5 |
| cf <i>P. marina</i> | 19 | 3 | 5 | 5 | 1 | | | | | 5 | 1 | | | | | 18 | 6 | | | | | 47 | 11 | |
| cf <i>Fregatta</i> sp. | 1 | 1 | | | | | | | | | | | | | | | | | | | | | 1 | 1 |
| cf <i>Oceanites nereis</i> | | | | | | | | | | | | | | | | 14 | 1 | | | | | | 14 | 1 |
| Storm petrel undet. | | | | | | | | | | | | | | | | 11 | 3 | | | | | | 41 | 9 |
| Procellariid size <i>P. griseus</i> | | | | | | | | | | | | | | | | | | | | | | | 4 | 2 |
| cf <i>Procellaria aequinoctialis</i> | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 |
| cf <i>Pterodroma lessonae</i> | | | | | | | | | 10 | 1 | | | | | | | | | | | | | 1 | 1 |
| <i>Coenocorypha aucklandica</i> | | | | | | | | | 24 | 3 | 30 | 4 | 29 | 3 | 37 | 8 | | | | | | | 22 | 3 |
| cf <i>C. aucklandica</i> | | | 15 | 4 | 2 | 2 | | | | | | | | | 16 | 2 | | | | | | | 157 | 25 |
| <i>Cyanoramphus</i> sp. | 4 | 1 | 1 | 1 | 18 | 2 | | | | | | | | | | | | | | | 6 | 1 | 50 | 10 |
| cf <i>Cyanoramphus</i> sp. | | | 1 | 1 | | | | | | | | | | | | | | | | | | | 1 | 1 |
| <i>Anas aucklandica</i> | | | 8 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | 11 | 4 |
| cf <i>A. aucklandica</i> | 15 | 1 | | | | | | | | | | | | | | | | | | | | | 24 | 2 |
| <i>Levinia muelleri</i> | | | 64 | 11 | 16 | 1 | | | | 25 | 2 | 52 | 5 | 69 | 7 | | | | | | | | 226 | 26 |
| cf <i>L. muelleri</i> | | | 8 | 1 | | | | | | | | | | | | | | | | | | | 11 | 2 |
| cf <i>Charadrius biceinctus</i> | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 |
| <i>Anthornis melanura</i> | 22 | 3 | 221 | 14 | 61 | 9 | 66 | 6 | | | | | | | | | | | | | | | 382 | 34 |
| cf <i>A. melanura</i> | 18 | 2 | 13 | 6 | 3 | 1 | | | | 10 | 1 | | | | 5 | 3 | | | | | | | 49 | 13 |
| <i>Petroica macrocephala</i> | 1 | 1 | | | | | | | | | | | | | | | | | | | | | 1 | 1 |
| <i>Anthus novaezelandiae</i> | | | | | | | | | | | | | | | | | | | | | | | 96 | 4 |
| cf <i>Turdus philomelos</i> | 1 | 1 | | | | | | | | | | | | | | | | | | | | | 6 | 2 |
| cf <i>Passer</i> | | | | | | | | | 5 | 1 | | | | | | | | | | | | | 2 | 1 |
| Passerine indet. | | | 1 | 1 | | | | | | | | | | | | | | | | | | | 8 | 7 |
| Total Birds | 72 | 8 | 352 | 49 | 383 | 48 | 153 | 18 | 148 | 13 | 97 | 15 | 121 | 24 | 256 | 39 | 6 | 1 | | | | | 1588 | 215 |
| Seabirds | 13 | 1 | 90 | 19 | 111 | 13 | 54 | 8 | 119 | 9 | 18 | 4 | 14 | 6 | 111 | 14 | 0 | 0 | | | | | 530 | 74 |
| Landbirds | 59 | 7 | 262 | 30 | 272 | 35 | 99 | 10 | 29 | 4 | 79 | 11 | 107 | 18 | 145 | 25 | 6 | 1 | | | | | 1058 | 141 |

Table 1. Summary data for the bone prey remains from New Zealand falcons on the Auckland Is. FBL, Fleming Bay (1993 collection); FBY, Fleming Bay DOC collection; MB, Maclaren Bay DOC collection; MB93, Maclaren Bay 1993 NH collection; SB, Survey Bay (DOC collection 1); SCB, South Cape Basin; FB, Fly Basin; SBMW, Survey Bay DOC collection 2; AI90, Fleming Bay DOC collection. FBY, MB, SB, SCB, AI90, SBMW, are summed data from DOC expeditions of 1991, 1996 and Dec 1997. NISP, Number of individual specimens; MNI, Minimum number of individuals.

as well. Close examination of the moss beneath favoured roosting sites also revealed 2 samples of rangle stones, which were also collected: falcons ingest a few stones, which are thought to aid digestion (Fox 1976).

The prey remains we collected were augmented with other sets of pellets collected by Kath Walker and Graeme Elliott, from Maclaren Bay, Fleming Bay, Fly Basin, South Cape Basin and Survey Bay, during the course of other work on Department of Conservation expeditions to the islands, in Feb 1991, Dec 1996 and Dec 1997. These nests were only visited once during the incubation period, and the samples analysed in a similar fashion, and the data are reported here.

All pellets were analysed at the Museum of New Zealand, Te Papa. The pellets were examined dry on a white laboratory tray and viewed macroscopically with a magnifying glass and dissecting microscope. They were teased apart with forceps and needle until separated and any identifiable features noted (e.g. mandibles, feathers, feet, claws and insect parts). Most bone material was either washed or gently brushed while dry to remove debris to enable its identification.

Bone fragments were identified by THW by comparison with modern reference skeletal material in the collection of the museum. Bones are catalogued in the Museum of New Zealand, Te Papa collections. The feather samples were identified by NH, by comparison with specimens from the study skin collection housed in the Museum of New Zealand, Te Papa.

For analysis, each pellet was treated as a single unit for which the Number of Individual Specimens (NISP) were counted for each taxon and the Minimum Number of Individuals (MNI) of prey represented by bones computed for it. Additional species represented by feathers were noted and added to the list for the pellet. An aggregate MNI for each site was determined from the sum of MNIs for each pellet.

We follow the nomenclature advocated by the Checklist Committee (O.S.N.Z. 2010).

RESULTS

The total diversity of prey species with the aggregate NISP and MNI for each species, for each site is shown in Table 1. The importance of prey species in the diet was assessed by conversion of the MNI for each taxon to the proportion of diet by weight (g) of each species (Table 2).

Feathers and rangle stones

A total of 24 samples of feathers from prey remains, excluding pellets, were collected. The quality of feather material within pellets varied greatly: most were bitten and masticated to some degree, and only feathers where vanes were relatively intact were able to be identified. Eleven species of birds were identified among the feather remains: white-headed petrel, sooty shearwater (*Puffinus griseus*), Antarctic prion, grey-backed storm-petrel (*Oceanites nereis*), subantarctic diving petrel (*Pelecanoides urinatrix exsul*), Auckland I teal, Auckland I snipe, red-crowned parakeet (*Cyanoramphus novaezelandiae*), Auckland I pipit, bellbird (*Anthornis melanura*) and blackbird (*Turdus merula*).

Two samples of rangle stones were found and measured. The first sample consisted of 11 stones with a total weight of 19.5 g and was found on the moss covered ground beneath a rata that provided a favoured perch for the adults. The 2 largest stones each weighed c.3 g and measured 22.5 mm x 15 mm, and 20.2 x 12.5 mm, respectively. The smallest stone weighed less than 0.5 g and its longest dimension was 10.7 mm. The large size of stones in this sample indicates that they were probably produced by the female falcon. A second sample of 4 stones with a total weight of 6 g was found on a moss covered stump used as a plucking post. The largest dimension of these stones averaged 10 mm and they had an average weight of 1.2 g. This smaller size suggests that they were likely produced by the male falcon.

Bones

A minimum of 18 species of bird were identified among a total 1588 bones (NISP) representing 215 individuals (MNI) in the prey remains of falcons collected on Auckland Is (Table 1). Eight of these species were seabirds, which accounted for 34% of the prey MNI (NISP=530, MNI=74). Most of the seabirds were small species such as diving petrels, prions and storm petrels. The frequency of species caught varied by location. For example, diving petrels dominated the seabird assemblage in Maclaren Bay, whereas in Fleming Bay, prions were the dominate prey item. We did not identify the prions or the diving petrels to species, but the size of the remains and associated feathers was consistent with their being Antarctic prion and subantarctic diving petrel, respectively, both of which are common breeding species in the area.

Table 2. Weight (g) of prey as percentage of diet of the Auckland I falcon. Taxon values are the sum of those for specimens certainly identified and those identified as similar to (cf) that taxon in Table 1. Prey weights from Heather & Robertson (1996), except for *Anas aucklandica*, from Marchant & Higgins (1990), *Charadrius bicinctus* from Marchant & Higgins (1993), *Petroica macrocephala* from Higgins & Peter (2002), and *Coenocorypha aucklandica* from Higgins & Davies (1996). The use of 'cf' implies specimens similar to.

| Taxon | Total MNI | Taxon weight | Sum of weight | % weight in diet |
|---------------------------------------|-----------|--------------|---------------|------------------|
| <i>Pelecanoides</i> sp. | 19 | 130 | 2470.0 | 11.1 |
| <i>Pachyptila</i> sp.+cf | 22 | 125 | 2750.0 | 12.4 |
| <i>Pelagodroma marina</i> +cf | 16 | 45 | 720.0 | 3.2 |
| cf <i>Fregatta</i> sp. | 1 | 55 | 55.0 | 0.2 |
| cf <i>Garrodia nereis</i> | 1 | 35 | 35.0 | 0.2 |
| Storm petrel | 9 | 55 | 495.0 | 2.2 |
| Procellariid size <i>P. griseus</i> | 2 | 800 | 1600.0 | 7.2 |
| cf <i>Procellaria aequinoctialis</i> | 1 | 1100 | 1100.0 | 4.9 |
| cf <i>Pterodroma lessoni</i> | 3 | 600 | 1800.0 | 8.1 |
| <i>Coenocorypha aucklandica</i> +cf | 33 | 100 | 3300.0 | 14.8 |
| <i>Cyanoramphus</i> sp. | 11 | 70 | 770.0 | 3.5 |
| <i>Anas aucklandica</i> | 6 | 425 | 2550.0 | 11.5 |
| <i>Lewinia muelleri</i> +cf | 28 | 90 | 2520.0 | 11.3 |
| cf <i>Charadrius bicinctus exilis</i> | 1 | 82 | 82.0 | 0.4 |
| <i>Anthornis melanura</i> +cf | 47 | 35 | 1645.0 | 7.4 |
| <i>Petroica macrocephala</i> | 1 | 14 | 14.0 | 0.1 |
| <i>Anthus novaeseelandiae</i> | 4 | 40 | 160.0 | 0.7 |
| cf <i>Turdus philomelos</i> | 2 | 70 | 140.0 | 0.6 |
| cf <i>Passer domesticus</i> | 1 | 30 | 30.0 | 0.1 |
| Totals | 208 | 3901 | 22236 | 100 |
| seabirds | 74 | 2945 | 11025 | 50 |
| landbirds | 134 | 956 | 11211 | 50.4 |

Among land birds, the most frequent prey were bellbirds (NISP=431, MNI=37). However, Auckland I snipe (NISP=190, MNI=33) had only slightly smaller MNI, and as they are much larger birds, were more important prey in biomass (Table 2). Similarly, the endemic rail *Lewinia muelleri* was taken as prey relatively frequently (NISP=237, MNI=28). Parakeets were taken much less frequently than these 3 main land bird taxa (NISP=50, MNI=11). Small native passerines, *Petroica* and *Anthus* were only occasional prey. Similarly, the introduced passerines such as *Turdus* species and sparrows (*Passer domesticus*) were minor prey items, and included one half-eaten blackbird, found cached under the base of an old rata branch that emerged from a mound of sphagnum.

DISCUSSION

Our analysis of pellets and prey remains indicates that the diet of New Zealand southern falcons

on the Auckland Is, is very different from that of falcons on mainland New Zealand: it is dominated by seabirds, but land-birds are also important. The relatively intact avifauna of the Auckland Is results in falcons preying mainly on native and endemic species. Although estimating the abundance of prey species was beyond the scope of this study, the high frequency of the most common species (i.e., bellbirds, procellariiform seabirds) suggests that falcons take prey in proportions representing their approximate availability and with seabirds, may also reflect the distribution of breeding colonies and localised hunting activity by falcons. Bellbirds appeared to be the most common land-bird in the coastal rata forest and shrubland (Buckingham *et al.* 1991; N.H., *pers. obs.*), and were also the most frequent terrestrial prey items in the diet of falcons. The high proportion of procellariiform seabirds in the diet of falcons is also not surprising given that the Auckland Is are home to many seabirds, with population estimates for

Antarctic prion alone, being about 1 million pairs (Marchant & Higgins 1990).

Rangle stones are believed to aid digestion, although how this is achieved in falcons is not fully understood. It is thought that they stir up grease and mucous lining the anterior digestive tract (Fox 1976). Fox observed with trained falcons, that some of this mucous is cast up on the stones and some is loosened and passes through the gut, giving their mutes (droppings) an oily appearance for a day or two. Rangle stones may play an important role in the diet of these southern falcons due to their high consumption of seabirds and therefore fattier diet, compared to the diet of mainly passerines and introduced-mammals of falcons on the main islands of New Zealand. Fox (1977) found that for eastern falcons, females had rangle stones about 15 mm diameter, and weighing 17-20 g per group, and males had rangle stones about 7 mm diameter, and weighing 8-10 g per group. The Auckland Is samples are quite similar by comparison.

How falcons in the Auckland Is capture their prey was not studied, but seabirds, such as diving petrels and prions, are probably taken on the ground or in flight, as they leave, or arrive at the breeding colonies. The marine peregrines (*Falco peregrinus pealei*) of the northwest Pacific coast, are crepuscular to semi-nocturnal in their hunting because of timing of movements to and from nests by seabirds (Beebe 1975), and the same is probably true for these southern falcons. Land birds, such as bellbirds, were probably taken either in flight or from trees. Flightless land birds were presumably taken on the ground, with birds such as rails, snipe and teal constituting c.37% of the diet by weight. This proportion would likely increase when petrels are not breeding and falcons must rely more on terrestrial prey. Future studies of the falcon diet would benefit from examining seasonal changes in prey composition and how this varies with the breeding seasons of their prey species.

Although falcons preyed on native birds, many of which would be vulnerable to introduced mammalian predators, it is unlikely that falcons threaten any native Auckland Is birds with extinction. For example, Buckingham *et al.* (1991) remarked that the wary behaviour of snipe and the fact that they did not call during the day, may be a response to the presence of falcons. He also noted that snipe on the Snares Is, where falcons do not occur, are conspicuous and call during both day and night. Similarly, the seabird species taken as prey (subantarctic diving petrels, prions, white-headed petrels and grey-backed storm petrels), are all strictly nocturnal on land (Warham 1990; Brooke & Prince 1991; Mougeot & Bretagnolle 2000), and this would protect them somewhat from the largely diurnal hunting behaviour of falcons. Such

adaptations may have evolved in response to falcon predation, but would not necessarily provide any protection against nocturnal predatory mammals.

Our observations on the Auckland Is confirms the reports of other writers that the New Zealand falcon is a diurnal hunter, but that it will also hunt in low light conditions to take advantage of nocturnal prey. Potts (1882) recorded them "hunting before dawn and by moonlight in June". Henry (1903 in Fox 1977: 161) wrote "they are sly and fly late in the evening and at the peep of day in the morning". McLean (1911), writing about their predation on native pigeons, said "most of the killing was done at daylight or late evening". Fox (1977) reported that New Zealand falcons at Hack, "would hunt in the evenings until it was too dark to see them". Other falcons, such as the hobby (*Falco subbuteo*), Eleonora's falcon (*F. eleonorae*) and kestrel (*F. tinnunculus*), have also been recorded hunting by moonlight (Martin 1990) and our observations of some largely nocturnal prey, suggests that the same may be true for New Zealand falcons in the Auckland Is. Indeed, NH observed crepuscular activity on 2 occasions when a pair of falcons was heard and seen flying over our camp in failing light. Nocturnal activity was also observed one evening when a falcon was heard kekking (calling), as it flew overhead at 10:15 pm on a calm moonlit night (Hyde 1994).

Seabirds have previously been reported in the diet of New Zealand falcons in several studies. Wilson (1959) found 2 "sparrow hawks" nests on Codfish I and observed that adults were mostly feeding their young on Cook's petrels. He remarked, "It seemed strange that a bush hawk should live on a seabird" (Wilson 1959), although a colony of Cook's petrels numbering >10,000 existed on the island. On mainland New Zealand, Harrow (1976) reported that Hutton's shearwater were abundant prey of falcons living in the valley below the colony in Kowhai Valley. These observations support the interpretation from analysis of fossil deposits that petrels, whose colonies were widespread in inland and coastal areas, were important prey items of falcons over much of New Zealand in the prehistoric past (Worthy 1997; Worthy & Holdaway 1995; Worthy *et al.* 2002; Worthy & Zhao 2006). The diet we have recorded for the Auckland Is falcons shows that in this subantarctic outpost for the species, available procellariiform seabirds are preyed upon.

The New Zealand falcon is not alone in taking seabirds. Breeding peregrine falcons feed predominately on 4 seabirds, comprising 2 alcids and 2 petrel species (Beebe 1975). In Fiji, peregrine falcons have also been recorded to take a variety of petrels and other seabirds, some of which were likely captured over the ocean (Worthy 2000). The diet of southern falcons on the Auckland Is is very

different from the present-day diets of the eastern and bush forms of New Zealand falcon. Like the peregrine, the New Zealand falcon is an adaptable predator, taking prey as available from a wide range of habitats and circumstances.

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