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New Zealand falcons (*Falco novaeseelandiae*) hunting petrels at night and underground during the day

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Abstract: New Zealand falcons (*Falco novaeseelandiae*) routinely feed on burrow-nesting seabirds (petrels: Procellariiformes) at several sites. As petrels are rarely present on the colony surface during daylight, and falcons are considered to be diurnal hunters, there has been much speculation about how falcons are able to capture petrels. We present evidence that New Zealand falcons are able to hunt petrels in forest at night, and also enter burrows during the day to extract chicks. These are novel hunting behaviours for falcons, and further increase the broad range of hunting strategies documented for New Zealand falcons. While these hunting methods may be used by only a few individual birds, they can produce high prey-capture rates.

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INTRODUCTION

New Zealand falcons (kārearea, *Falco novaeseelandiae*) are versatile foragers compared to other falcon species (Seaton & Hyde 2021). Seven different aerial hunting techniques were described for them by Fox (1977, and in Marchant & Higgins 1993), combining methods used by short-winged forest hawks (Accipitridae: *Accipiter* spp.) and open-country falcons (Falconidae: *Falco* spp.) elsewhere in the world. New Zealand falcons can also extract nestlings from tree-hole or crevice nests (Marchant & Higgins 1993), and they can hunt on the ground: they have been observed hunting for ground-level bellbird (*Anthornis melanura*) nests and chicks among tree roots on the subantarctic Auckland Islands (Miskelly *et al*. 2020a). New Zealand falcons on the ground have also been observed stalking and catching skinks (*Oligosoma* spp.) on mown grass on Takapourewa/Stephens Island in the outer Marlborough Sounds (AdG *pers. obs*.), and attempting to do so among sand dunes on Whenua

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Hou/Codfish Island (Jake Osborne *pers. comm*. to CMM, 10 September 2021).

Falcons worldwide are generally regarded as diurnal predators, relying on acute eyesight to locate prey, often from great distances (Brown & Amadon 1968; Marchant & Higgins 1993; del Hoyo *et al*. 1994). However, New Zealand falcons have frequently been reported as having consumed species of burrow-nesting petrels (Procellariiformes: Procellariidae, Hydrobatidae, and Pelecanoididae) that visit their breeding colonies only at night (Wilson 1959; Harrow 1976; Chance 1992; Worthy & Holdaway 1995; Worthy 1997; Worthy *et al*. 2002; Worthy & Zhao 2006; Hyde & Worthy 2010; Cuthbert 2017; Miskelly *et al*. 2019, 2020; Elliott *et al*. 2020). There has been much speculation on how falcons are able to capture these petrels, including suggestions that falcons are catching birds out at sea, or catching birds that arrive at the colony before it is fully dark, or birds that depart late, when there is sufficient light for falcons to begin hunting (Harrow 1976; Worthy & Zhao 2006; Hyde & Worthy 2010; Cuthbert 2017; Elliott *et al*. 2020). We document two previously unreported hunting methods used by New Zealand falcons to capture petrels: hunting at night under forest, and entering burrows during the day. These behaviours further extend the diverse repertoire of hunting behaviours recorded for New Zealand falcons.

STUDY SITES AND METHODS

All observations were serendipitous encounters or recordings made during other conservation research, management, or leisure activities. Evidence of New Zealand falcons hunting mottled petrels (kōrure, *Pterodroma inexpectata*) in the middle of the night was obtained at two widely separated colonies in Fiordland, and a falcon was observed catching fairy prion (tītī wainui, *Pachyptila turtur*) chicks inside burrows on Takapourewa/Stephens Island in the Marlborough Sounds. Observation and recording methods are described under each study site below.

Lake Hauroko

'Motukōrure' islet (0.3 ha) lies 500 m south of Mary Island in Lake Hauroko, eastern Fiordland. It is usually free of introduced mammals and had an estimated 530 mottled petrel burrows in December 2019 (Miskelly *et al*. 2021). Following evidence of stoats (*Mustela erminea*) and then mice (*Mus musculus*) reaching the islet in mid-2020, trail cameras were installed on the islet as part of a successful pest mammal incursion response. Three cameras were installed on 28 May 2020, and then replaced with a single 'permanent' camera (Browning Dark Ops Apex, model BTC-6HD-APX) on 12 August 2020. This was the last date that evidence of stoats was detected on the islet, with two stoat corpses found in traps.

The single camera in place from August 2020 monitored activity over about 30 m^2 of forest floor, with the branches of 4–5 trees also close enough for large birds in them to trigger the motion-sensor. The camera was set to record 10 seconds of video whenever the motion-sensor was triggered. The islet was visited again by Department of Conservation staff on 9 October, 19 November, and 14 December 2020, and 29 January, 18 February, 1 April, 7 May, 11 June, and 4 August 2021, with the SD card from the camera removed and replaced on each occasion. Mottled petrel corpses were searched for on the colony surface, and either photographed or the corpses retrieved to determine cause of death.

Any video clip with a falcon in it was classified as 'falcon activity'. Records of falcon activity within 30 minutes of each other were considered to be part of the same falcon visitation event. These were classified as 'day' if between sunrise and sunset, 'dusk' during the hour after sunset, and 'night' from then until an hour before sunrise. No falcons were detected in the hour before sunrise. All times are reported in New Zealand Standard Time. Percentage moon disc illumination was obtained from the website https://lunaf.com/lunar-calendar, viewed 15 August 2021.

In February 2011, the first calls by mottled petrels flying over the colony were heard 27–38 minutes after sunset (average = 33 minutes, n = 7; Matt Rayner *pers. comm*. to CMM, 30 August 2021).

Anchor Island

An estimated 700 mottled petrel burrows were found on the largest islet in Anchor Island Harbour in Dusky Sound, Fiordland, in November 2016 (Miskelly *et al*. 2017). CMM camped on the islet on the night of 27–28 February 2021, as part of a four-person research team collecting viral swab samples from mottled petrels and sooty shearwaters (*Ardenna grisea*). Direct observations of mottled petrels and a New Zealand falcon were made between 2145–0110 h and 0415–0635 h.

Takapourewa/Stephens Island

AdG and Polly Hall were the Department of Conservation rangers on Takapourewa/ Stephens Island at the northern tip of the Marlborough Sounds during 2012–15. A pair of falcons was resident on the island, and successfully fledged two chicks in each of the 2012–13 and 2013–14 breeding seasons.

Takapourewa holds the world's largest fairy prion (*Pachyptila turtur*) colony, with an estimated

Table 1. Details of five occasions when a New Zealand falcon was filmed being active at night, or feeding on or carrying a mottled petrel corpse. All footage was captured on a trail camera set within a mottled petrel colony on a 0.3 ha islet in Lake Hauroko, Fiordland, in 2021. Shading is used to highlight nocturnal activity by the falcon or falcons. All times have been converted to New Zealand Standard Time. Lunar disc illumination is given as "% moon" under Day/Night (see Methods).

Date	Time (h)	Day/Night	Description
4 Feb	0403	Night 49% moon	Falcon attacking petrel, flying from tree to ground; tussle for 3 seconds, then falcon on ground looking away from petrel (which is out of sight)
15 Feb	2010	Dusk	Falcon flies up to tree perch carrying petrel (windy conditions), then flies further along perch, still carrying petrel. Many feathers on ground and being blown about
19 Feb	2040	Dusk	Falcon drags petrel carcass in from left to front of camera, using one foot. It proceeds to pluck the carcass and then feed over the next 17 min
25 May	0028	Night 99% moon	Falcon on ground, walks towards camera, with feather stuck to beak then pecks at something (out of camera, in foreground); 6 min later falcon walks away from the camera, to edge of bank
7 June	1818	Night 8% moon	Falcon on ground, to the left near the camera. Moves off to left out of frame

1.4 million pairs (Craig 2010; Jamieson *et al*. 2016). Fairy prions breed synchronously, with chicks on Takapourewa fledging from late January to mid-February (Miskelly & Gummer 2013). Before mid-January, prion chicks were not seen outside of their natal burrows by day or night, unless their burrows were flooded by an extreme rain event.

AdG was reading a book on the veranda of the rangers' house, in late December 2013, when he made the direct observation of a New Zealand falcon catching fairy prion chicks described below.

RESULTS

New Zealand falcon predation on mottled petrels based on prey remains

Three beheaded mottled petrel corpses were found on Motukōrure islet on 18 February 2021. Based on images of these, Graeme Taylor, Chifuyu Horikoshi, and Noel Hyde considered that they had been killed by a falcon (*pers. comms* to LMcL). At least 10 petrel carcasses were seen on 1 April 2020, a fresh carcass was noted on 7 May, and 26 carcasses were recovered on 11 June 2021 (these may have included all the previous corpses recorded). Fourteen of the mottled petrel corpses that were removed from the islet in May and June were confirmed as likely to have been killed by falcons, either in the field or during necropsy and skeleton preparation at Te Papa (authors, *pers. obs*.). The corpses included both adults and pre-fledged chicks.

Three sites where a falcon had plucked mottled petrels were found on the islet in Anchor Island Harbour during the evening of 27 February 2021. However, the team was unaware of any falcons being present on the 0.3 ha islet before they retired to their tents at 0110 h.

Nocturnal hunting

Video evidence

Video footage of a falcon (possibly a single adult) on Motukōrure islet was captured in 75 video clips during 53 falcon visitation events on 37 dates between 22 January and 7 June 2021. Video evidence of the falcon or falcons being active at night, and/or interacting with live or dead petrels, is summarised in Table 1. These included sequences of a falcon attacking an adult mottled petrel at night (4 February; Figs 1A & B), a falcon flying to a perch carrying a petrel corpse (15 February), and a falcon plucking a mottled petrel corpse (19 February; Fig. 1C).

Most of the falcon activity was during the day (75%), with 19% at dusk, and five video clips (three events = 6 %) at night. These clips showed the falcon (or falcons) as being active in the middle of the night: at 0403 h on 4 February 2021 (the attack sequence described below), at 0028 h, 0029 h, & 0034 h on 25 May 2021, and at 1818 h on 7 June 2021. This last event was 1 h 6 min after sunset.

On 25 May, an adult falcon walked towards the camera (Fig. 1D) and then pecked at an apparent prey item on the ground that was too close to be in the camera field of view. Six minutes later, the falcon walked away from the camera. This date was one day before full moon (and had 99% illumination); however, local cloud cover conditions were not recorded on any date.

Figure 1. A & B) Two frames from a video showing a New Zealand falcon attacking a mottled petrel on an islet in Lake Hauroko, Fiordland, filmed at 0403 h on 4 February 2021. The bright spots are the eye-shines of both birds. A link to the video clip is provided in Supplementary materials. C) A New Zealand falcon plucking a mottled petrel corpse on an islet in Lake Hauroko, Fiordland, filmed at 2046 h on 19 February 2021. D) A New Zealand falcon walking around at night at a mottled petrel colony on an islet in Lake Hauroko, Fiordland, filmed at 0028 h on 25 May 2021.

The moon was ¾ full on 4 February (49% illumination), when a falcon was recorded attacking a mottled petrel (Figs 1 & B).[1] The adult petrel was likely leaving the colony before dawn (it was 1 h 46 min before sunrise), and was moving rapidly downslope, partially obscured by the surface topography. The falcon bounded down a sloping tree trunk towards the petrel, and then attacked it largely out of camera view, below the crest of a low bank. Flailing wingtips were visible for about 3 seconds, before the falcon re-appeared facing away from where the petrel had apparently escaped downhill.

Direct observation

An adult New Zealand falcon was disturbed from a freshly killed (still warm) adult mottled petrel on the islet in Anchor Island Harbour at 0440 h on 28 February 2021. It was a still, clear night with a full moon (100% illumination), although it was dark under the dense *Olearia* canopy (sunrise was at 0628 h). The site where the kill occurred had been visited multiple times earlier in the night. The falcon scrambled up a sloping trunk in CMM's headlamp beam and flew out through the canopy.

Hunting underground

Direct observation

The falcons on Takapourewa used live prion chicks each year to teach their fledglings how to catch prey in mid-air, and how to kill prey. The adult female falcon was frequently observed from late December to February carrying downy prion chicks and calling to her fledglings, before dropping the live prion chick for them to attempt to catch. If they failed to catch the falling chick, it was not retrieved, and the female would fly off to catch another chick.

At *c.* 1500 h on an unrecorded date in late December 2013, an adult female New Zealand falcon landed near the rangers' house on Takapourewa, ran under a hedge, then emerged soon after with a prion chick. This was used for a training session with the two fledglings nearby, but was soon dropped and lost in the long grass. The adult female returned to the hedge on two further occasions, and each time she was observed entering a prion burrow and disappearing out of site, before emerging backwards 5–10 seconds later dragging a live prion chick with her beak. Once on the mown lawn by the house, the prion chick was transferred to one foot before an ungainly running take-off with the heavy load.

The two burrows that the falcon was seen to enter were close together (and near the site where the first of the three prion chicks was caught). One of these burrows was inspected by AdG. It had a wide entrance leading to multiple prion nest chambers, all of which were beyond the length of his arm.

On other occasions, the adult female was observed emerging with a prion chick from the same patch of forest several times in quick succession, without the method of prion chick capture being observed. However, the impression was that she routinely entered prion burrows, as there is no other way that she was likely to have been able to catch the concealed prion chicks so rapidly.

Video evidence

The trail camera on Motukōrure islet recorded a falcon walking on the ground on 45 occasions (85% of visitation events) between 22 January and 7 June 2021. No falcons were detected during the previous

[1] See also video supplementary material: https://www.youtube.com/watch?v=bKej-T20pwo

eight months or the succeeding two months. Although the bird was not seen inspecting or entering a burrow, there were no burrow entrances within the field of view – the camera was focused on a bait lure (intended to attract stoats) above a patch of flat ground with little ground cover.

DISCUSSION

Falcons hunting at night

Nocturnal hunting by falcons away from artificial lights is rarely reported. The low incidence of falcons being recorded on video at night on Motukōrure Islet (plus the single observation from Anchor Island) indicate that nocturnal hunting may be a rare behaviour, with night activity focussed on bright moonlit nights. However, it is possible that the Motukōrure falcon had favoured nocturnal hunting sites (e.g. areas with a more open canopy) elsewhere on the island, where activity would not have been recorded by the single camera present.

The only other report of a New Zealand falcon hunting in the middle of the night that we are aware of was told to Noel Hyde by Mr Robin Bagge of Tauranga, on 28 March 2009 (Noel Hyde *pers. comm.* to CMM, 22 July 2021). Robin Bagge worked for the New Zealand Forest Service and was a keen hunter. In 1978, while deer hunting with Stan Lowe in the middle reaches of Horomanga Stream, Murupara, they heard the squawking of a bird at 0200 h. Robin shone his spotlight up a tree and saw a falcon (presumed to be a male, based on its size) holding a still alive, flapping sacred kingfisher (*Todiramphus sanctus*). When questioned as to how bright the night sky was, he replied that he never hunted on a full moon, suggesting that the kingfisher had been caught at much less than 100% lunar illumination.

Potts (1882: 44) reported that "On Banks Peninsula we have observed it [New Zealand falcon], in the wintry month of June, hawking by the light of the waning moon, ere the little owl [likely *Ninox novaeseelandiae*], warned by the coming of day, has retired to the dim obscurity of its roost in the decayed tree." However, the reference to an owl going to roost indicates that this observation was pre-dawn rather than during complete darkness.

Many falcon species hunt in dim light after sunset and before dawn (Brown & Amadon 1968; Ratcliffe 1980; del Hoyo *et al*. 1994); however, we have found limited evidence of falcons hunting by natural light in the middle of the night. The numerous accounts of peregrine falcons (*Falco peregrinus*) hunting at night were mainly of birds in urban settings using artificial light to locate their prey (e.g. Rejt 2004; DeCandido & Allen 2006; Kettel *et al*. 2016; Time 2016). Similar behaviour has been reported for common kestrels (*F. tinnunculus*), lesser kestrels (*F. naumanni*), sooty falcons (*F. concolor*), and Eleanora's falcons (*F. eleanorae*) (Sachslehner 1996; Negro *et al*. 2000; Gschweng 2013; Buij & Gschweng 2017).

Satellite-tracking or GPS data loggers have revealed some lesser kestrels and Eleanora's falcons to be active at night in areas away from artificial illumination, particularly when moon disc illumination was >60% (Gustin *et al*. 2014; Buij & Gschweng 2017). However, the nearest comparable accounts that we have found of falcons hunting at night under natural light (or at sites with little artificial illumination) were two studies of peregrine falcons hunting seabirds at their breeding colonies, and one account of a duck being taken.

Wynn *et al*. (2010) used infrared cameras to detect nocturnal predation of Balearic shearwaters (*Puffinus mauretanicus*) by a peregrine falcon on bare ground at a cave entrance on the island of Menorca. At least 18 shearwaters were killed over two breeding seasons, at a rate of about 0.5 kills per night over a 2-month period, with most attacks occurring on moonlit nights (Wynn *et al*. 2010). It is unclear whether the cave entrance received artificial illumination, although the authors mention a tourist development nearby, and that "Artificial lights from these developments may assist night hunting Peregrines" (Wynn *et al*. 2010).

Collins *et al*. (2014) also used infrared cameras, installed at a black-legged kittiwake (*Rissa tridactyla*) colony on a cliff on Puffin Island, Wales, and detected predation of kittiwake chicks by a peregrine falcon. The two predation events captured by the camera occurred 53 mins and 48 mins before sunrise, 2 days apart: "It would not have been completely dark during predation events, thus it is possible that the peregrine was using the low-light conditions to enhance its chance of predation success" (Collins *et al*. 2014).

Hirata *et al*. (2013) reported a peregrine falcon that killed a mallard (*Anas platyrhynchos*) 40 minutes before sunrise, in an area with minimal artificial lighting in Hokkaido, Japan (Hirata *et al*. 2013). The snow-covered open ground may have facilitated detection of the dark-plumaged prey in the low light conditions.

In all three situations described by Wynn *et al*. (2010), Hirata *et al*. (2013), and Collins *et al*. (2014), the peregrine falcons were hunting in open, uncluttered environments, and may have been utilising artificial light, or light from the sun in the hour before sunrise. These circumstances were unlike the complex environments under dense canopy where we recorded New Zealand falcons attacking or feeding on mottled petrels more than 100 minutes before sunrise.

Falcons entering burrows to catch seabird chicks

Although a falcon was observed entering petrel burrows on a single date only, we interpret the regular presence of a falcon on the ground at a dense mottled petrel colony during daylight (as detected by video) as circumstantial evidence that the bird was searching for petrel chicks inside burrows. The falcon was recorded only during the nestling period for mottled petrels (Warham *et al.* 1977), and it spent much of this time walking over the colony surface. The high recording rate (a minimum of 37 days over 4 months) is noteworthy, given the tiny patch of forest floor in the camera field of view. The highest density recorded for falcons on mainland New Zealand is about one pair per 900 ha (Seaton & Hyde 2021), although the Takapourewa falcons probably confined their hunting to the 150 ha island while breeding. Falcons have never been recorded nesting on 0.3 ha Motukōrure islet; however, at least one adult falcon visited the islet sufficiently often in 2021 to be detected on a single trail camera (viewing less than 1% of the islet) on at least 27% of days during the mottled petrel nestling period. When combined with the recovery of at least 26 mottled petrel corpses (including of pre-fledged chicks) during this time, and the apparent absence of stoats on the islet in 2021, we suspect that the falcon was routinely entering burrows during daylight to extract petrel chicks, as observed on Takapourewa.

We have not found any published accounts of falcons hunting underground. However, Noel Hyde (*pers. comm*. to CMM, 23 July 2021) described a trained New Zealand falcon entering a burrow when in pursuit of a rabbit (*Oryctolagus cuniculus*): "*Some years ago, a female bush falcon I was flying perched on a post. We noticed it started head bobbing and focussing intently on a rabbit about 200 m away. The falcon quickly launched into a direct flying attack, and as it closed in, at the last moment the rabbit bolted. The rabbit sprinted across the paddocks about 150 m with the falcon in hot pursuit about 3 m behind. The rabbit disappeared down a burrow, and to our amazement the falcon followed the rabbit into the burrow at speed. On running over and looking in, the falcon was nearly an arm-length down the burrow, with the young rabbit firmly in its clutches. I had to reach in and gently wriggle, and pull the falcon out with her still firmly attached to the rabbit*." This active pursuit of fleeing prey into a burrow differs from falcons hunting petrel chicks, which remain stationary in a nest chamber at the end of a long burrow during daylight, and only begin to emerge (at night) in the week or so before fledging (Warham 1996).

Falcon predation of petrels in Fiordland

Hunting of mottled petrels by falcons on Motukōrure islet has been sporadic, rather than continuous, over the past 47 years, suggesting that it is self-acquired behaviour by perhaps only two individual birds. The first report of mottled petrels on the islet was by Tom Neave and his daughter Rosemary in May 1974 (Wynston Cooper *pers. comm*. to CMM, 28 August 2021). The 2–3 partial skeletons that Tom Neave forwarded to the National Museum via the Wildlife Service for identification were considered by curator Sandy Bartle to have been killed by a falcon (Wynston Cooper *ibid*.).

Wynston Cooper monitored the Motukōrure mottled petrel colony during 31 visits between 1982 and 1987, and never observed a falcon on the islet (Wynston Cooper *ibid*.). Similarly, no evidence of falcons, or falcon predation of petrels, was detected during at least annual visits to the islet between 2008 and 2020 (Colin Bishop and Jenny Rickett *pers. comm*. to CMM, 30 August 2021). Matt Rayner camped on the islet for 26 days between 2009 and 2011; he found no evidence of predation, but heard a falcon calling over the island on a single occasion (Matt Rayner *pers. comm*. to CMM, 30 August 2021).

Evidence of falcons having fed on at least ten broad-billed prions (*Pachyptila vittata*) was found at five colonies on the outer Fiordland coast during 2017 and 2019 (Miskelly *et al*. 2019, 2020b). This included an adult falcon that was disturbed from a freshly killed (and mostly consumed) adult prion on an islet off the south coast of Passage Island in Chalky Inlet at 1700 h on 23 November 2017 (CMM, *pers. obs*.; photograph in Te Papa blog 'Seabird discoveries in remote southern Fiordland', published 5 December 2017). We were unable to determine how these prions were captured. However, we did not encounter any on the surface or flying over any of the 28 Fiordland colonies surveyed during daylight in 2016–2020 (Miskelly *et al*. 2021; CMM *pers. obs*.).

While the multiple records of New Zealand falcons feeding on broad-billed prions at their breeding colonies in Fiordland indicate that falcons may be hunting at night or underground, there are other ways that they may have captured the petrels. These large-headed prions are prone to getting caught by the neck in tree forks (e.g. illustration in Cemmick & Veitch 1985: 45), and it is possible that falcons were attracted to the flailing wings of trapped prions after day-break. We consider it unlikely that falcons were catching mottled petrels or broad-billed prions at sea before dark (e.g. as Clunie 1976 reported for a peregrine falcon hunting collared petrels *Pterodroma brevipes* and tropical shearwaters *Puffinus bailloni* in Fiji). We never saw these petrels from land before complete darkness, and the islets that they breed on are tiny specks near much larger landmasses with numerous potential perches or landing sites for falcons (i.e. it is unlikely that falcons returning from the sea

carrying a petrel would land on a Fiordland petrel colony to feed on it).

Apart from Fiordland and the Marlborough Sounds, there are few other places where New Zealand falcons currently co-occur with dense colonies of breeding petrels. Petrels of six species formed a major portion of the diet of New Zealand falcons on Adams Island in the subantarctic Auckland Islands (Hyde & Worthy 2010; Elliott *et al*. 2020; Miskelly *et al*. 2020). Harrow (1976) and Cuthbert (2017) reported New Zealand falcons feeding on Hutton's shearwaters (*Puffinus huttoni*) in the Seaward Kaikoura ranges and suggested that they were catching departing birds in the half-light of dawn. When combined with our observations, these accounts from Kaikoura and the Auckland Islands reveal that New Zealand falcons readily exploit burrow-nesting seabirds as a food resource when present, and that they use a variety of hunting techniques to capture them, including hunting at night, and entering burrows. Studies using monitoring devices attached to falcons (including GPS, light sensors, and tri-axial accelerometers) and a network of trail cameras could be used to determine how often each method is used by individual birds and local populations, and the proportion of petrel burrows inspected or entered.

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LITERATURE CITED

Brown, L.H.; Amadon, D. 1968. *Eagles, hawks and falcons of the world*. 2 volumes. Feltham, UK, Country Life Books. 945 pp.

Buij, R.; Gschweng, M. 2017. Nocturnal hunting by Eleonora's falcons *Falco eleonorae* on their breeding and non-breeding grounds. *Acta Ornithologica 52*: 35–49.

Cemmick, D.; Veitch, D. 1985. *Black robin country; the Chatham Islands and its wildlife*. Auckland, Hodder & Stoughton. 135 pp.

Chance, G.R. 1992. Falcons in the subantarctic. *OSNZ News 62*: 8.

Clunie, F. 1976. A Fiji peregrine (*Falco peregrinus*) in an urban-marine environment. *Notornis 23*: 8–28.

Collins, P.M.; Green, J.A.; Dodd, S.; Shaw, P.J.; Halsey, L.G. 2014. Predation of black-legged kittiwake chicks *Rissa tridactyla* by a peregrine falcon *Falco peregrinus*: insights from time-lapse cameras. *Wilson Journal of Ornithology 126*: 158–161.

Craig, E.D. 2010. Takapourewa titiwainui (fairy prion; *Pachyptila turtur*): how nest site selection affects breeding success, with applications for translocation. Unpublished MSc thesis, University of Otago.

Cuthbert, R.J. *Seabirds beyond the mountain crest: the history, natural history and conservation of Hutton's shearwater*. Dunedin, Otago University Press. 220 pp.

DeCandido, R.; Allen, D. 2006. Nocturnal hunting by peregrine falcons at the Empire State Building, New York City. *Wilson Journal of Ornithology 118*: 53–58.

del Hoyo, J.; Elliot, A.; Sargatal, J. (*eds*) 1994. *Handbook of the birds of the world*. *New world vultures to guineafowl*. *Volume 2*. Barcelona, Lynx Edicions. 638 pp.

Elliott, G.P.; Walker, K.J.; Parker, G.C.; Rexer-Huber, K.; Miskelly, C.M. 2020. Subantarctic Adams Island and its birdlife. *Notornis 67*: 153–187.

Fox, N.C. 1977. The biology of the New Zealand falcon (*Falco novaeseelandiae* Gmelin 1788). Unpublished PhD thesis, University of Canterbury, Christchurch. 421 pp.

Gschweng, M. 2013. Sooty falcon *Falco concolor*. Pp 231–233 *In*: Safford, R.J.; Hawkins, A.F.A. (eds) *The birds of Africa*. Vol. 7. The Malagasy Regions. London, Christopher Helm.

Gustin, M.; Ferrarini, A.; Giglio, G.; Pellegrino, S.C.; Frassanito, A. 2014. First evidence of widespread nocturnal activity of lesser kestrel (*Falco naumanni*) in southern Italy. *Ornis Fennica 91*: 256–260.

Harrow, G. 1976. Some observations of Hutton's shearwater. *Notornis 23*: 269–288.

Hirata, K.; Nakahama, S.; Yoshioka, T. 2013. Hunting in the dark by a peregrine falcon (*Falco peregrinus*). *Slovak Raptor Journal 7*: 85–87.

Hyde, N.H.S.; Worthy, T.H. 2010. The diet of New Zealand falcons (*Falco novaeseelandiae*) on the Auckland Islands, New Zealand. *Notornis 57*: 19–26.

Jamieson, S.E.; Tennyson, A.J.D.; Wilson, K.-J.;

Crotty, E.; Miskelly, C.M.; Taylor, G.A.; Waugh, S.M. 2016. A review of the distribution and size of prion (*Pachyptila* spp.) colonies throughout New Zealand. *Tuhinga 27*: 56–80.

Kettel, F.F.; Gentle, L.K.; Yarnell, R.W. 2016. Evidence of an urban peregrine falcon (*Falco peregrinus*) feeding young at night. *Journal of Raptor Research 50*: 321–323.

Marchant, S.; Higgins, P.J. (*eds*) 1993. *Handbook of Australian, New Zealand & Antarctic Birds. Vol. 2, raptors to lapwings*. Melbourne, Oxford University Press. 984 pp.

Miskelly, C.M.; Bishop, C.R.; Greene, T.C.; Rickett, J.; Taylor, G.A.; Tennyson, A.J.D. 2020b. Breeding petrels of Breaksea and Dusky Sounds, Fiordland; responses to three decades of predator control. *Notornis 67*: 543–557.

Miskelly, C.M.; Bishop, C.R.; Taylor, G.A.; Tennyson, A.J.D. 2019. Breeding petrels of Chalky and Preservation Inlets, southern Fiordland – a test of the 'refugia from resident stoats' hypothesis. *Notornis 66*: 74–90.

Miskelly, C.M.; Bishop, C.R.; Tennyson, A.J.D. 2021. Breeding petrels of northern and central Fiordland, with a summary of petrel populations for the Fiordland region. *Notornis 68*: 194–207.

Miskelly, C.M.; Elliott, G.P.; Parker, G.C.; Rexer-Huber, K.; Russ, R.B.; Taylor, R.H.; Tennyson, A.J.D.; Walker, K.J. 2020a. Birds of the Auckland Islands, New Zealand subantarctic. *Notornis 67*: 59–151.

Miskelly, C.M.; Gummer, H. 2013. Attempts to anchor pelagic fairy prions (*Pachyptila turtur*) to their release site on Mana Island. *Notornis 60*: 29–40

Miskelly, C.M.; Tennyson, A.J.D.; Stahl, J.-C.; Smart, A.F.; Edmonds, H.K.; McMurtrie, P.G. 2017. Breeding petrels of Dusky Sound, Fiordland – survivors from a century of stoat invasions. *Notornis 64*: 136–153.

Negro, J.J.; Bustamante, J.; Melguizo, C.; Ruiz, J.L.; Grande, J.M. 2000. Nocturnal activity of lesser kestrels under artificial lighting conditions in Seville, Spain. *Journal of Raptor Research 34*: 327–329.

Potts, T.H. 1882. *Out in the open: a budget of scraps of natural history gathered in New Zealand*. Christchurch, Lyttelton Times Co. Ltd. 301 pp.

Ratcliffe, D. 1980. *The peregrine falcon*. Vermillion, South Dakota, Buteo Books. 416 pp.

Rejt, L. 2004. Nocturnal feeding of young by urban peregrine falcons (*Falco peregrinus*) in Warsaw (Poland). *Polish Journal of Ecology 52*: 63–68.

Sachslehner, L.M. 1996. [Nocturnal active common kestrel (*Falco tinnunculus* L.) hunting Noctuidae at the illuminated Saint Stephan's Cathedral in Vienna. Are kestrels capable of UV vision?]. Ökologie der Vögel 18: 55–64.

Seaton, R.; Hyde, N. 2013 [updated 2021]. New Zealand falcon. *In:* Miskelly, C.M. (*ed.*) *New Zealand Birds Online*. www.nzbirdsonline.org.nz [viewed 29 July 2021].

Time, B.E. 2016. Hunting activity by urban peregrine falcons (*Falco peregrinus*) during autumn and winter in south-west Norway. *Ornis Norvegica 39*: 39–44.

Warham, J. 1996. *The behaviour, population biology and physiology of the petrels*. London, Academic Press. 613 pp.

Warham, J.; Keeley, B.R.; Wilson, G.J. 1977. Breeding of the mottled petrel. *Auk 94*: 1–17.

Wilson, R. 1959. *Bird islands of New Zealand*. Christchurch, Whitcomb and Tombs. 202 pp.

Worthy, T.H. 1997. The Quaternary fossil fauna of South Canterbury, South Island, New Zealand. *Journal of the Royal Society of New Zealand 27*: 67–162.

Worthy, T.H.; Holdaway R.N. 1995. Quaternary fossil faunas from caves on Mt Cookson, North Canterbury, South Island, New Zealand. *Journal of the Royal Society of New Zealand 25*: 333–370.

Worthy, T.H.; Holdaway R.N.; Alloway B.V.; Jones J.; Winn J.; Turner D. 2002. A rich Pleistocene – Holocene avifaunal sequence from Te Waka #1: terrestrial fossil vertebrate faunas from inland Hawke's Bay, North Island, New Zealand. Part 2. *Tuhinga, Records of the Museum of New Zealand Te Papa Tongarewa 13*: 1–38.

Worthy, T.H.; Zhao J.X. 2006. A late Pleistocene predator-accumulated avifauna from Kids Cave, West Coast, South Island, New Zealand. *Alcheringa Special Issue 1*: 389–408.