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Hand-rearing and translocation trial of the critically endangered kuaka Whenua Hou (Whenua Hou diving petrel; *Pelecanoides georgicus whenuahouensis*)

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Abstract: The critically endangered kuaka Whenua Hou (Whenua Hou diving petrel, *Pelecanoides georgicus whenuahouensis*) is a burrow-nesting petrel, restricted to breeding in the foredunes of Whenua Hou. The species' recovery is inhibited by ongoing threats such as vessel-based light pollution, interspecific competition, and climate change including storm-induced erosion of fragile breeding habitat and thus, kuaka Whenua Hou would benefit from the establishment of a new colony through translocation. However, translocations of petrels require hand-rearing of pre-fledging chicks on the destination site to reset their philopatric behaviour. We documented a hand-rearing and translocation trial of kuaka Whenua Hou in preparation for future translocations. Ten kuaka Whenua Hou chicks were translocated from natal burrows to nest boxes installed behind the colony, and hand-reared on a bespoke diet of pureed sardines. All hand-reared chicks fledged successfully, with fledging mass similar to naturally-reared chicks and with slightly longer wing lengths. The techniques used highlighted the importance of selection criteria, access to natural growth curves to infer feeding regimes, nutritionally rich diets, and strict hygiene protocols. Our trial provides a knowledge base for future translocations and the establishment of new kuaka Whenua Hou colonies.

Tuhinga whakarāpopoto: He momo tata korehāhā te kuaka o Whenua Hou (*Pelecanoides georgicus whenuahouensis*), he momo ōi e whai rua hei kōhanga, kua mau ki te whakatipu ki ngā tāhuahua kopī o mua o Whenua Hou. Ko te whakarauora o tēnei momo kua whakanguengue i ngā āhuatanga whakaraerae e mau tonu pērā i te pokanga rama, ā rātou ake pakanga ki a rātou me te hurihuri o te āhuarangi, tae noa atu ki te horonga whenua o te pūrei kōhanga marore nō te marangai, ā nō reira, ka whai hua te kuaka Whenua Hou i te whakatūtanga atu o tētahi taiwhenua hou mā te nukunuku kōhanga. Engari, me whakatipu ngā pīrere ki te ringa ki te wāhi e tū ai te kōhanga hou kia ea ai te nuku kōhanga, ā, kia tautuhi anō tā rātou hiahia ki te hoki atu ki te kāinga i whakatipuria kētia rātou. I āta mārama mātou ki te whakamātautau o te whakatipu ā-ringa me te nukunuku kōhanga o te kuaka Whenua Hou kia whakarite ai ki te nukunukunga tūturu e haere ake nei. I nuku kia ngahuru ngā pīpī kuaka Whenua Hou mai i ngā rua i whānau mai ai rātou ki ētahi kōhanga hanga i whakatūria ki muri i te taiwhenua matua, ā, i whakatipuria rātou ki te ringa ki ētahi kai ake o te hārini penupenu. I whai huruhuru pai ngā pīpī katoa, ā, ehara i te rerekē te taumaha o ēnei pīpī i ērā i whakatipuria ki ō rātou ake kōhanga, engari he paku roa ake ngā parirau. I whakamiramira atu ngā tū-āhua i whakamahia i te hiranga o ngā paearu whiri, te whai wāhitanga ki ngā pikinga whakatipu māori kia whakapae tika ai te tikanga whāngai, te whiringa o te kai taioranga me ngā tikanga akuaku mārō. Ka noho tā mātou whakamātautau hei tūāpapa mātauranga ki ngā nukunukunga kōhanga e haere ake nei, me te whakatūtanga o ētahi taiwhenua hou mō ngā kuaka Whenua Hou.

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Keywords: Hand-rearing diet, chick nutrition, growth curves, conservation, endangered species, seabirds, Codfish Island, Aotearoa New Zealand

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INTRODUCTION

Seabirds have key ecological roles, serving as indicators of environmental changes in the marine ecosystem and providing important marine-terrestrial linkages such as nutrient transport (Mulder & Keall 2001; Parsons *et al*. 2008; Pizarro *et al*. 2012; Signa *et al*. 2021). However, increased anthropogenic pressures have led to widespread population declines and range restrictions, resulting in seabirds being one of the most threatened taxonomic groups on the planet (Croxall *et al*. 2012; Dias *et al*. 2019). Seabirds are impacted by multiple threats including invasive predators, by-catch in commercial fisheries, habitat degradation, pollution, sea-level rise, and climate change (Taylor 2000a; Baker *et al*. 2006; Jones *et al*. 2008; Dias *et al*. 2019; Rodriguez *et al.* 2019). These threats affect various seabirds in different ways, highlighting the importance of targeted conservation techniques to restore species.

Translocation is an established and effective technique that involves the intentional movement of species from one location to another for conservation or restoration goals (Seddon *et al*. 2007; Seddon 2010). This technique is used to overcome dispersal barriers, reinforce existing populations, re-establish extirpated populations, and increase ranges by establishing new populations (Fischer & Lindenmayer 2000; Gummer 2003; Miskelly & Taylor 2004; Deguchi *et al*. 2011). Translocation techniques have been adapted for many threatened seabirds, including Procellariiformes (tube-nosed seabirds, including petrels) (Miskelly & Taylor 2004; Miskelly *et al*. 2009; Deguchi *et al*. 2011; Piludu *et al*. 2018; VanderWerf *et al*. 2019; Spatz *et al.* 2023). For translocations of petrels, incorporating hand-rearing of pre-fledging chicks at the destination site is required to reset their innate homing instinct (Gummer 2003; Miskelly *et al*. 2009). This has proven to be successful with >100 seabird translocations events successfully implemented around the world (Spatz *et al.* 2023).

The critically endangered kuaka Whenua Hou (Whenua Hou diving petrel, *Pelecanoides georgicus whenuahouensis*) is a recently-described burrow-nesting petrel for which translocation has been identified as an important step to secure its long-term survival (Fischer *et al*. 2018c, 2023). Kuaka Whenua Hou was once widespread with a historical distribution including Rēkohu (Chatham Islands), Rakiura (Stewart Island), and Te Waipounamu (South Island of New Zealand) (Taylor 2000b; Holdaway *et al*. 2003; Wood & Briden 2008; Fischer *et al*. 2017b; Tennyson 2020). Introduction of invasive predators such as rats (*Rattus* spp.) led to multiple local extinctions and the last remaining colony of kuaka Whenua Hou is now found on Whenua Hou (Codfish Island), where the adult population numbers ~200 individuals (Taylor 2000b; Fischer *et al*. 2018b, 2020b). Despite the eradication of invasive predators from Whenua Hou in 2000, pressure from ongoing threats including vessel-based light pollution, interspecific competition for burrows, and climate change including storm-induced erosion of fragile breeding habitat, resulting in direct mortality, is inhibiting kuaka population recovery (Fischer *et al*. 2017a, 2018b, 2020b, 2023).

Translocation of kuaka Whenua Hou may reduce the impact of ongoing threats and thus are key to the long-term survival of the species (Fischer *et al.* 2023). To ensure the future success of kuaka Whenua Hou translocations, a key component, the hand-rearing of chicks, must be tested. While protocols for the closely related common diving petrel (kuaka, *Pelecanoides urinatrix*) and other small petrels exist (Miskelly & Taylor 2004; Gummer & Gardner-Gee 2009; Miskelly *et al*. 2009), it is uncertain whether these protocols are also suitable for kuaka Whenua Hou.

We assessed whether existing hand-rearing protocols developed for kuaka are suitable for kuaka Whenua Hou. To achieve this, we monitored chick survival and condition and aimed to answer the following questions: (1) Do hand-reared chicks fledge at equal to/or better condition than naturally-reared chicks? (2) Do hand-reared chicks have the same fledging phenology as naturally-reared chicks? The development and fine-tuning of hand-rearing techniques for kuaka Whenua Hou chicks is a crucial part of the larger kuaka Whenua Hou recovery programme (Fischer *et al*. 2023). Here, we report on the first test translocation.

MATERIALS & METHODS

Study site

The only extant kuaka Whenua Hou colony is found on Whenua Hou, located 3 km off the west coast of Rakiura, Aotearoa (New Zealand; Fischer *et al*. 2017a, 2018b). All kuaka Whenua Hou burrows are confined to a small 20 m wide strip of sand dunes (0.018 km^2) located within Waikoropupū (Sealers Bay; 46.766°S, 167.645°E). The test translocation site (Fig. 1) was located in the back dunes behind the main colony (Fischer *et al*. 2018b). This site was chosen because of its distance from the springtide line (18 m), its central location in respect to the rest of the kuaka Whenua Hou colony, the absence of active burrows, the absence of known archaeological sites (Fischer & Tucker 2020), and its accessibility.

Chick collection

A total of 10 kuaka Whenua Hou chicks were located in their natal burrows using a burrowscope (Sextant Technologies, Wellington) and subsequently collected by hand. Shallow burrows <80 cm depth

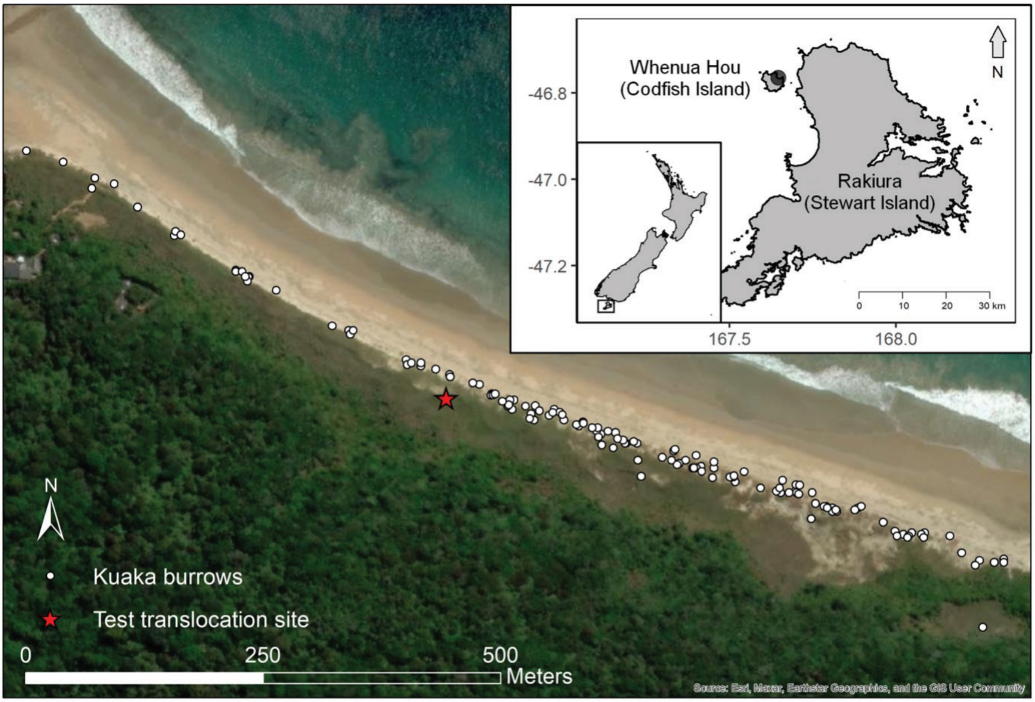

Figure 1. Location of the test translocation site, in relation to kuaka Whenua Hou (*Pelecanoides georgicus whenuahouensis*) burrows, within the dunes of Waikoropupū (Sealers Bay), Whenua Hou

were targeted for easy extraction. Additionally, burrows more at risk of erosion from future storm events were favoured. Criteria for translocation candidates were adapted from Fischer *et al*. (2021). Specifically, chicks were selected if they exhibited a wing length of 100–110 mm and a mass of >130 g, which in combination indicated healthy chicks at 10–7 days before fledging (DBF; Fischer *et al*. 2021). Suitable fledglings were transported in cloth bags to nest boxes (20–400 m; transportation time <5 min). Chick collection commenced on the 28 December 2022 with two chicks transferred to burrows, followed by five chicks on 29 December, and the final three chicks on 30 December.

Artificial nest boxes

Chicks were individually housed in the back dune behind the main colony, in customised artificial nest boxes following an existing design specific to this species (Fischer *et al*. 2018a). Ten multi-level nest boxes were installed in October 2022 with mana whenua at ~60 cm underground (Fig. 2). The nest boxes were built from 12 mm plywood, with a design consisting of an open-bottom brood chamber (25 x 25 x 15 cm), insulating sand layer (25 x 25 x 5 cm) with an insulated access hatch (10 x 15 x 5 cm), an access shaft (25 x 25 x 40 cm) and external access door (30 x 30 x 1.2 cm). To mimic dark natural tunnels, artificial nest box tunnels were inserted with a curved profile and reinforced with Novacoil© piping (length = ~150 cm; diameter = 11 cm). As an additional insulation measure, sandbags (83 x 48 cm) were placed on top of external access doors (Miskelly *et al*. 2009; Fischer *et al*. 2018a). Tunnel entrances were initially obstructed with wooden blockades to facilitate chicks acclimating to surroundings and prevent premature fledging. Blockades were removed based on chick condition and behaviour, on average 4.9 days (range: 3–7 days) after chick transfer.

Hand-rearing chicks

Fledglings were hand-reared following protocols developed for the closely related common diving petrels (kuaka, *Pelecanoides urinatrix*) (Miskelly & Taylor 2004; Gummer & Gardner-Gee 2009; Miskelly *et al*. 2009). Initial feeding of chicks did not commence until the day after extraction of chicks from natal burrows to reduce stress. Fledglings were fed a pureed sardine diet prepared by blending sardines (two 106 g tins of Brunswick sardines in soya oil and one 106 g tin of Pams sardines in soya oil, with excess oil removed), 210 ml of cooled pre-boiled water, 60 ml of Melrose Omega fish

Figure 2. Installation process of customised artificial nest boxes, for translocated kuaka Whenua Hou (*Pelecanoides georgicus whenuahouensis*) chicks in the back dunes of Whenua Hou. Photographs: Johannes Fischer.

oil + Vitamin D and one crushed Mazuri® Vitazu™ Small Bird Supplement with Vitamin A tablet. This mixture was delivered via 14 Fg Jorvet PVC feeding tubes cut down to 70 mm x 4.66 mm and fed to chicks once daily. Chicks were fed at the Whenua Hou field station, rather than directly at the test translocation site to allow for strict hygiene practices following best practice guidelines for burrow-nesting petrels (Gummer & Gardner-Gee 2009; Gummer *et al*. 2014). Chicks were transported from the test translocation site to the field station in transfer boxes with ice packs to reduce heat stress. Feeding portions were designed to mimic natural feeding regimes, but finetuned to individual chick growth, and thus smaller portions were delivered as chicks neared fledging. On average, chicks were fed 8.65 ml (range: 3–20 ml) portions of the pureed sardine diet, but on occasion, chicks close to fledging were fed small portions of fish oil only, on average 4.3 ml (range: 2–5 ml) to avoid weighing them down, while still providing them with additional energy to fledge. Kuaka Whenua Hou chicks were hand-reared an average of nine days before fledging (range: 5–12 days).

Targets considered for optimum fledging condition included meeting or exceeding mean natural fledging mass: 112.1 g (range: 90–130 g; mean adult mass: 124 g, excluding masses collected during chick-rearing period) and mean natural fledging wing length: 113.6 mm (range: 110–119 mm; mean adult wing length 120 mm). Hand-reared chicks were measured daily using a wing ruler for wing length (flattened wing cord; mm) and an electronic scale for mass (g) prior to feeding. Naturally-reared chicks were mostly handled and measured only once during banding within ~two weeks prior to fledging. Direct mass comparisons showed that Pesola (used in previous seasons' mass measurements of naturally-reared chicks) and electronic scales performed equally well and thus, no confounding factors were introduced due to the use of two different measuring tools. To assess fledging phenology all nest boxes, as well as natural burrows with previously banded chicks, were monitored daily using stick palisades placed at tunnel entrances to record fledging activity of chicks until fledging had occurred.

Data analysis

To assess the success of the trial, growth curve (mass and wing length) and phenology data of hand-reared and naturally-reared chicks (pre-existing datasets 2017–2022) were compared. Specifically, differences in fledging mass and wing length (i.e. at DBF = 0) between hand-reared (n = 10 individuals) and naturally-reared chicks (n = 216 individuals) were compared using t-tests. Linear models (LMs) were fit to growth curve data during the last 12 DBF to investigate the effect of the translocation on kuaka Whenua Hou chick mass loss and wing growth. These models included a fixed effect of DBF and translocation status (i.e. hand-reared or naturally-reared) as well as an interactive effect between both. The first day following chick translocation was excluded for each translocated chick, as development during the first day these was not controlled by hand-rearers. To compare differences in fledging phenology (i.e. timing of DBF = 0) between hand-reared (n = 10 individuals) and naturally-reared chicks (n = 125 individuals), fledging dates were initially transformed into a numerical variable (i.e. days since 31 December) and then, a non-parametric Wilcoxon test was performed to address non-normal parameter distributions. All statistical analysis and graphical visualisations were completed using Program R (R Core Team 2020; version 4.1.3).

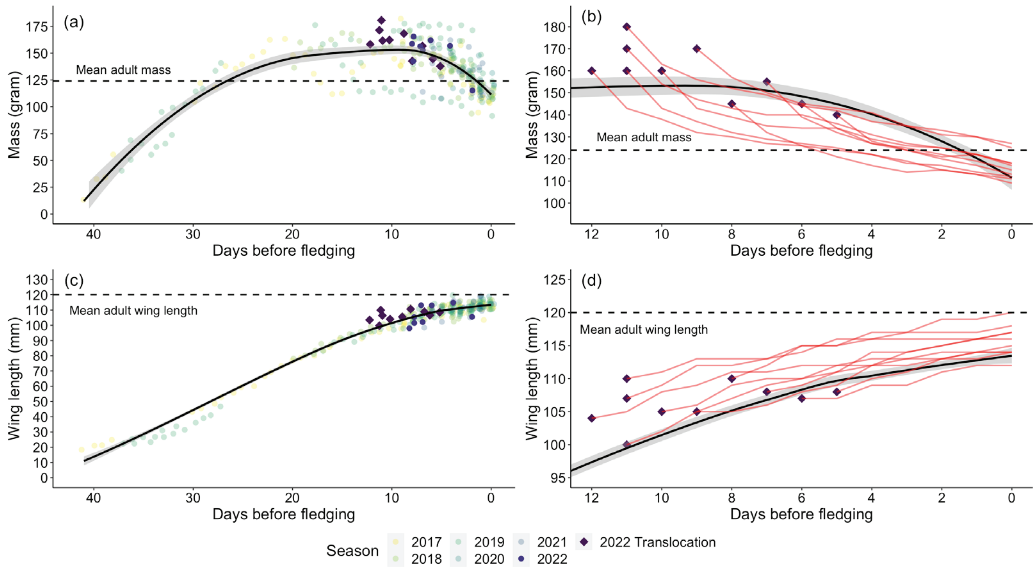

Figure 3. (a) Kuaka Whenua Hou mass growth curves of naturally-reared chicks, (b) mass trajectories of individual translocated chicks, (c) naturally-reared chick growth curves of wing length, (d) and wing length growth trajectories of individual translocated chicks. Mean mass growth curves of naturally-reared chicks are illustrated by locally estimated scatterplot smoother (LOESS) curves (black lines).

RESULTS

Fledging condition

All 10 hand-reared kuaka Whenua Hou chicks survived the trial and fledged at average mass and with above average wing lengths (Fig. 3). Hand-reared chicks exhibited similar fledging mass as naturally-reared chicks (mean ± SE: 116.5 ± 1.85 g vs 112.1 ± 2.03 g for hand-reared and naturally-reared, respectively; t_{27} = -1.41, p = 0.17; Fig. 3). However, hand-reared chicks fledged with a slightly longer wing lengths than naturally-reared chicks (115.7 ± 0.75 mm vs 113.6 ± 0.53 mm for hand-reared and naturally-reared, respectively; t_{28} = -2.35, p = 0.03). Mass loss was influenced by DBF (LM estimates ± SE; R^2 = 0.42, $F_{2,301}$ = 73.62, $p < 0.001$; β = 3.92 ± 0.30, $p < 0.001$), whereas the translocation treatment and interaction showed no impact (β = -3.31 ± 3.10, p = 0.29, β = -0.85 ± 0.59, p = 0.15 for translocation status and the interaction, respectively). In other words, modelled daily mass loss of chicks was approx. 4 g/day and no discernible effect of the translocation was evident. Wing growth was influenced by DBF, translocation status, and the interaction between both (R^2 = 0.61, $F_{3,300}$ = 157.3, $p < 0.001$; β = -1.19 ± 0.06, $p < 0.001$, β = 1.62 ± 0.66, p = 0.02, β = 0.39 ± 0.13, p = 0.002 for DBF, translocation and their interaction, respectively). In other words, wing growth for naturally-reared chicks was approx. 1.2 mm/day, while wing growth for hand-reared chicks was approx. 1.6 mm/day, resulting in longer wings at fledging.

Fledging phenology

All hand-reared kuaka Whenua Hou chicks successfully fledged within the anticipated ~2-week period, between 4–11 January 2023, with a mean fledging date of 8 January (Fig. 4). Timing of fledging for hand-reared chicks was slightly earlier on average compared to naturally-reared chicks,

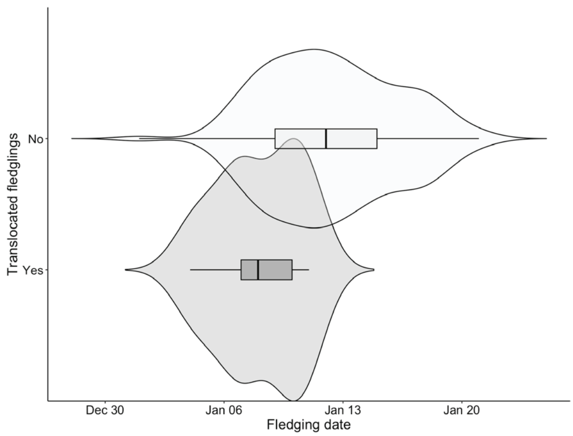

Figure 4. Kuaka Whenua Hou phenology of translocated fledglings and the six-year average of naturally-reared fledglings displayed as violin plots. The width of the plots represents the density of the data, while the box plot illustrates the interquartile range and median, depicted as the solid black line.

with the multiyear average having a mean fledging date of the 12 January (Wilcoxon test, W = 1019, $p < 0.001$).

DISCUSSION

Our study demonstrated that existing hand-rearing protocols developed for kuaka are indeed suitable for future kuaka Whenua Hou translocations. All translocated kuaka Whenua Hou chicks survived and fledged at equal, or better, condition when compared to naturally-reared chicks. Specifically, fledging mass for both groups were similar, while hand-reared chicks exhibited slightly longer wing lengths (Fischer *et al.* 2021). A potential reason for this may be that our hand-rearing diet facilitated faster wing growth and/or that daily feeding allowed additional wing growth, compared to the pre-fledging fasting that naturally-reared chicks experience.

Our trial was successful and can inform future translocations, provided some key deviations from previous protocols are accounted for. Similar to kuaka feeding protocols (Miskelly & Taylor 2004; Miskelly *et al*. 2009), kuaka Whenua Hou chicks were fed daily. However, it should be noted that we aimed to mirror natural mass loss trajectories and thus reduced feeding portions when necessary. This contrasts with kuaka feeding portions which were constant and much larger (8.65 ml on average for kuaka Whenua Hou vs 25–27.2 g for kuaka; Miskelly & Taylor 2004; Miskelly *et al*. 2009). However, it should be noted that our diets were more nutritionally rich due to the additional fish oil used, allowing us to mimic natural petrel diets and deliver smaller portions (Jensen 2021).

A crucial observation made during this study was the importance of access to existing natural growth curves when inferring feeding regimes. Petrels can be hand-reared on a universal artificial diet (Miskelly *et al*. 2009), which we used in this trial. However, species from the same genus may exhibit different mass loss strategies prior to fledging. Kuaka Whenua Hou tend to fledge below mean adult mass, while kuaka fledge at or above adult mass (Miskelly *et al.* 2009; Fischer *et al.* 2021), an important difference that must be accounted for during hand-rearing. These differences in mass loss strategies are evident in other seabird species pairs. Yelkouan shearwater (*Puffinus yelkouan*) and providence petrels (*Pterodroma solandri*), fledge below adult mass (Binder *et al*. 2013; Piludu *et al*. 2018), while closely-related Manx shearwaters (*Puffinus puffinus*) and ōi (grey-faced petrels; *Pterodroma gouldi*), respectively, fledge at similar or above adult mass (Hamer & Hill 1997; Ramos *et al*. 2003; Miskelly *et al*. 2009; Eizenberg *et al*. 2021). Pre-fledging mass recession (increasing chick mass gain, peaking above adult mass, followed by pre-fledging mass loss) is common in Procellariiformes (Gray & Hamer 2001), but the reason for fledging below adult mass is unknown. Possible functions could include inducing fledging or optimising wing loading, which is important for manoeuvrability and catching prey (Morbey *et al.* 1999; Wright *et al*. 2006; Goodpaster & Ritchison 2014). Yet, fledging at higher mass is often correlated with increased post-fledging survival (Perrins *et al*. 1973). A possible reason for kuaka Whenua Hou exhibiting lighter fledging mass may be that extra mass prevents fledging and limits a chicks ability to fly (Perrins *et al*. 1973; Sagar & Horning 1998; Mauck & Ricklefs 2005). Lack of pre-fledging emergence behaviour in kuaka Whenua Hou (Fischer *et al*. 2021) may also limit the ability to fledge at higher mass, as emergences allows for flight training of wing muscles, and without this training, lower mass may be necessary for liftoff (Yoda *et al*. 2016). The underlying drivers of mass loss strategies of individual species requires further investigation.

Our findings indicated that hand-reared chicks fledged earlier than naturally-reared chicks. However, this difference may be an artifact of collection timing and selection criteria. Specifically, our criteria (wing length = 100–110 mm, mass >130 g), which we applied in late December, may have caused the earlier cohort to be favoured (Fischer *et al*. 2021). Regardless, kuaka Whenua Hou chicks can fledge earlier than the mean fledging date. Additionally, chicks need to be hand-reared for a sufficient amount of time to enable the resetting of their homing instinct, as required for any future translocation off island (Gummer 2003; Miskelly *et al*. 2009). Kuaka Whenua Hou chicks were hand-reared for a sufficient period (5–12 days), based on results from previous kuaka translocations during which translocated chicks returned to the destination site (Mana Island) after being present for 2–3 days before fledging only (Miskelly & Taylor 2004; Miskelly *et al*. 2009). Our study thus reinforces that our selection criteria were appropriate for future translocations.

Following this successful test translocation, we recommend taking the next step in the kuaka Whenua Hou recovery process and translocate kuaka Whenua Hou to a new site. Only ~200 kuaka Whenua Hou remain on Whenua Hou. Furthermore, the ongoing impacts of environmental changes, storm-induced erosion of breeding habitat, competition for burrows, and vessel-based light pollution are inhibiting population recovery (Fischer *et al*. 2017a, 2020b, 2021). The establishment of a new colony through translocation is crucial for the long-term survival of this species and our successful trial paved a way forward to achieving this key goal.

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Changes in a New Zealand wetland bird community following creation of a predator-fenced sanctuary

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Abstract: There is limited information available on how New Zealand wetland bird communities respond to removal of mammalian predators, and reintroduction of locally extinct species. The forested Zealandia Te Māra a Tāne sanctuary in Wellington is surrounded by a mammal predator-exclusion fence, and contains two small lakes (2.7 and 1.1 ha). Counts of all visible wetland bird species were used to assess changes in the Zealandia wetland bird community over 28 years. This included a 3-year block of counts before the fence was built in 1999. Flocks of up to 143 southern black-backed gulls (karoro, *Larus dominicanus*) bathed on the larger lake before the catchment was opened to the public after 1999. Brown teal (pāteke, *Anas chlorotis*) and New Zealand scaup (pāpango, *Aythya novaeseelandiae*) both established resident breeding populations following releases of captive-reared birds between 2000 and 2003. Little shag (kawaupaka, *Microcarbo melanoleucos*), black shag (māpunga, *Phalacrocorax carbo*) and pied shag (kāruhiruhi, *P. varius*) all colonised naturally, and started breeding in 2003, 2008, and 2009 respectively. Paradise shelducks (pūtangitangi, *Tadorna variegata*) increased after the sanctuary was created, although numbers remained small (mean counts of *c.* 5 birds). Numbers of mallards (*Anas platyrhynchos*) were unaffected by creation of the sanctuary; however, there was an unexplained decline after 2016. Overall, the wetland bird community in Zealandia has become more diverse over time, and with a higher proportion of native and endemic species. However, we suggest that some of these changes (particularly the establishment of a large breeding colony of pied shags) might well have occurred even if the sanctuary had not been created.

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Keywords: conservation management, fence, Karori Sanctuary, pest eradication, predation, restoration, translocation, wetland bird, Zealandia Te Māra a Tāne

INTRODUCTION

Eradication and exclusion of introduced mammalian predators is a major focus of conservation management in New Zealand (Russell *et al*. 2015; Parliamentary Commissioner for the Environment 2017; Anonymous 2017). Mammalian predators have been eradicated from more than 70 New Zealand islands (Bellingham *et al*. 2010; Keitt *et al*. 2011), and by 2019 there were seven forested sanctuaries surrounded by predator-resistant fences (Burns *et al.* 2012; Innes *et al*. 2012, 2019; Butler *et*

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al. 2014). As a result of this conservation effort and associated monitoring, there is a growing body of information on how endemic forest birds and forest bird communities respond to mammalian predator suppression and eradication (Miskelly 2018; Fea *et al*. 2020). Several endemic forest birds that had disappeared from the mainland have successfully reestablished within fenced sanctuaries following translocations (Burns *et al.* 2012; Miskelly & Powlesland 2013; Smuts-Kennedy & Parker 2013; Butler *et al*. 2014; Azar & Bell 2016), and there is increasing evidence that 'deep endemic' species (i.e. those that are endemic at order, family, or genus level) benefit the most from predator suppression, and that they are able to out-compete 'shallow endemic' and non-endemic bird species provided that mammalian predators are absent or at low densities (Miskelly 2018; Binny *et al*. 2020; Fea *et al*. 2020). As a result, predator exclusion or suppression can create a trophic cascade, leading to forest bird communities with a greater abundance and diversity of deep endemic species, and lower abundance of species that have arrived in New Zealand more recently (Miskelly 2018; Binny *et al*. 2020; Fea *et al*. 2020; Miskelly *et al*. 2021).

In contrast to forest bird communities, little is known about how New Zealand wetland bird communities respond to eradication of predatory mammals. There are few wetlands on islands that have been cleared of predators (exceptions include Kapiti Island and Tuhua/Mayor Island), and few wetlands within predator-fenced sanctuaries (exceptions include Rotokare in Taranaki and Zealandia Te Māra a Tāne in Wellington). While bird monitoring has been undertaken at some of these sites (e.g. Miskelly & Robertson 2002; Bell 2015; Miskelly 2018), information on changes in their wetland bird communities following predator eradications has not yet been published. The only study that we are aware of that investigated wetland bird responses to pest mammal exclusion using a fence was at Ruataniwha wetlands in inland Canterbury (Sanders *et al.* 2007). An electrified fence and low-intensity trapping were used to exclude feral cats (*Felis catus*) and ferrets (*Mustela furo*) from 39 ha of the wetland, although Norway rats (*Rattus norvegicus*) and mice (*Mus musculus*) remained abundant inside the fence (Sanders *et al.* 2007). Hatching success for banded dotterels (*Charadrius bicinctus*) was significantly higher inside the fence; however, fledgling success was significantly lower, and none of the other wetland bird species monitored showed a clear benefit from the fence (Sanders *et al.* 2007). Sanders *et al.* (2007) concluded that their results did not support ongoing use of the design of predator-fence installed at the site.

We report on changes in the wetland bird community at two small lakes in Zealandia Sanctuary, Wellington (Lynch 2019), following exclusion of predatory mammals and releases of two endemic duck species. Our analyses are based on a series of counts that were initiated before the sanctuary was created, and continued at intervals through to 2023.

METHODS

Study sites

Zealandia Te Māra a Tāne (Karori Sanctuary, 41°18′S, 174°44′E) is situated in a 3 km-long valley between the suburbs of Karori and Highbury in Wellington, New Zealand. The sanctuary is predominantly forested, apart from two small lakes (*c*. 150 and 170 m above sea level) that were created to provide water for Wellington city through construction of dams in 1876–78 (lower reservoir) and 1906–08 (upper reservoir) (Lynch 2019). Although decommissioned in the late 1990s, the lower reservoir (2.7 ha) remains at its designed water level. The upper reservoir was lowered to its current level in 1991 (Lynch 2019) and now covers only 1.1 ha.

The lower reservoir and surrounding slopes were enclosed by a 2-metre high fence to discourage human access while the lake was managed as a water storage reservoir. Access to the area around the lower reservoir remained restricted throughout the transition from water supply to predator-fenced sanctuary, whereas there were informal walking tracks around the upper reservoir before it was included within the fenced sanctuary now known as Zealandia Te Māra a Tāne. The sanctuary (225 ha, including both lakes) was enclosed by an 8.5 km-long predator-proof fence in 1999, and all introduced mammal species were eradicated the same year (Campbell-Hunt 2002; Lynch 2019). Mice (*Mus musculus*) reinvaded the sanctuary within a year, and have subsequently been controlled to low densities in the valley (Lynch 2019).

The lower reservoir was temporarily drained to about 6 m below its usual water level during March–May 2021, following which rotenone (a piscicide) was applied on 13 May, with the aim of eradicating introduced redfin perch (*Perca fluviatilis*) (Shanahan *et al*. 2022). The water level was fully restored by late June 2021 (Shanahan *et al*. 2022).

Access tracks run along the top of the two dams and the eastern sides of both lakes, providing view points for essentially all birds on the water surface and most birds roosting on the lake edges.

Study design, data collection and analysis

Direct counts of all wetland birds present on the two lakes were made from lakeside vantage points during quarterly bird counts undertaken by Ornithological Society of New Zealand (OSNZ) members during 1995–98 (before the fence was built and pest mammals eradicated), 2002–05, and 2013–16. Changes in the forest bird community detected during counts from these three count blocks were summarised by Miskelly (2018). Ben Bell (BDB) began an ongoing series of walking transect counts that included the lakes, undertaken approximately every 3 weeks, from August 2011 (Bell 2015). These counts covered the entire 3 years of the 2013–16 OSNZ counts, and so we pooled data from both sets of counts. BDB's wetland bird data from the same four months (January, April, July, and October) between July 2020 and April 2023 were also included in the analyses, to provide a fourth 3-year block of quarterly counts (2020–23). Data on wetland bird populations were collected using the same methodology and vantage points throughout these 28 years.

We collated counts for each month and year, and retained the maximum count for each species for each of the two lakes. Counts for each lake are discussed separately in the text accounts for some species, but were added together to provide whole-of-sanctuary population estimates for each species for the graphical and statistical summaries.

Means and standard errors for each species each month within each 3-year block are presented graphically for the nine most frequently recorded wetland bird species. The samples sizes (3 maximum counts per month per count block) were too small for statistical analyses for each month, and so we combined 3 years of consecutive quarterly counts to allow statistical comparisons for each species between the four count blocks.

Maximum counts for each species within each count block were compared using Kruskal-Wallis analysis of variance. Counts between blocks were considered to be significantly different if $P<0.05$.

RESULTS

Gulls

Apart from occasional records of red-billed gull (tarāpunga, *Chroicocephalus novaehollandiae scopulinus* – see Appendix 1), the only gull species recorded from Zealandia was southern black-backed gull (karoro, *Larus dominicanus*). Large flocks of karoro scavenged at the Southern Landfill rubbish dump, *c.* 3 km south of Zealandia, throughout the study. During 1995–1998, flocks of up to 143 karoro regularly flew in from the Southern Landfill and bathed in the lower reservoir (Fig. 1). The flocks ceased using the valley after mammals were eradicated and the lower valley was opened to human visitors, with the average number of karoro present dropping from 48.8 per count session in 1995–1998 to 2.0 for the remainder of the study period (Fig. 1).

A single pair of karoro nested beside the lower reservoir during 2021–22 and 2022–23, and fledged two chicks in 2022–23 (Chris Gee & Raewyn

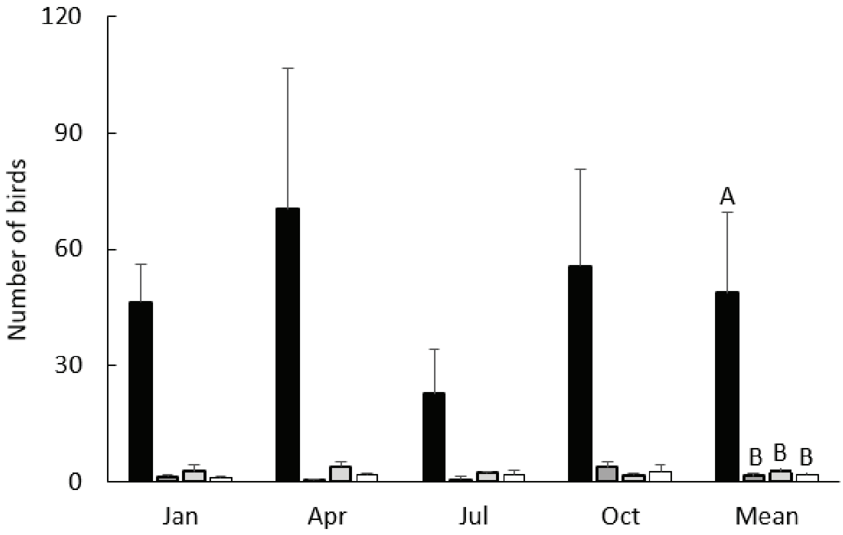

Figure 1. Southern black-backed gull / karoro counts in Zealandia sanctuary. Each bar represents the mean + standard error of the maximum count (lower + upper lake) for three consecutive years: 1995–98 (before the fence was built, black), 2002–05 (dark grey), 2013–16 (light grey), 2020–23 (white). Bars that share the same letter don't differ significantly (at P = 0.05).

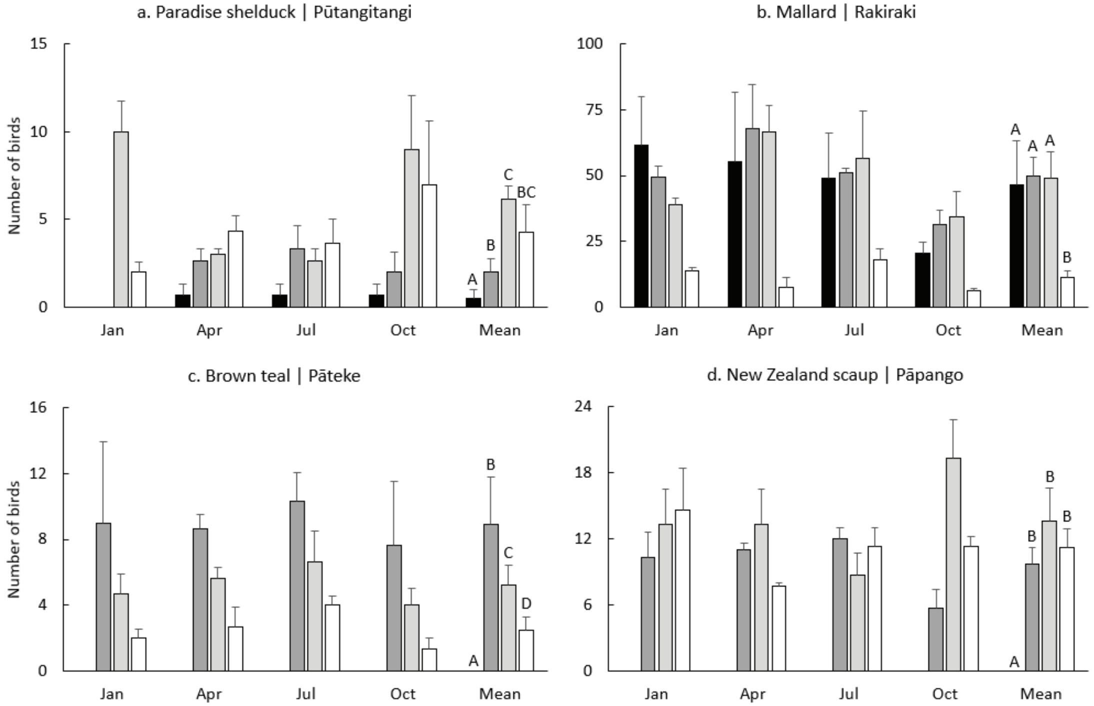

Figure 2. Duck (Anatidae) counts in Zealandia sanctuary. Each bar represents the mean + standard error of the maximum count (lower + upper lake) for three consecutive years: 1995–98 (before the fence was built, black), 2002–05 (dark grey), 2013–16 (light grey), 2020–23 (white). Note that brown teal and New Zealand scaup were not present in 1995–98. Bars that share the same letter don't differ significantly (at P = 0.05).

Empson, *pers. comms*). More than 100 "gulls and shags" gathered to feed on culled redfin perch in the lower reservoir in May 2021 (Shanahan *et al*. 2022), with 31 karoro recorded on 14 May (BDB, *pers. obs.*), the day after rotenone was applied (note that this temporary increase was not detected in the quarterly counts).

Ducks

The non-native mallard (rakiraki, *Anas platyrhynchos*) was the most abundant duck species in Zealandia throughout the 28-year study period (Fig. 2b). Their numbers remained unchanged (at an average count of 48.6 birds) after mammals were eradicated, but dropped significantly to a mean of 11.4 after 2016 (Fig. 2b). Mallard numbers were higher on the upper reservoir during 2020–23 (82% of the total, on average), and the large decline had already been detected in three of the quarterly counts before the lower reservoir was drained and rotenone applied there in May 2021 (BDB, *pers. obs.*).

Three endemic duck species were the only other Anatiformes that were frequently present in Zealandia (Fig. 2 and Appendix 1), with paradise shelduck (pūtangitangi, *Tadorna variegata*) present in low numbers when pest mammals were present (Fig. 2a). Shelduck counts increased significantly after mammals were eradicated, and continued to increase after 2005, after which they stabilised at a mean count of 5.2 birds per count session, with counts peaking when ducklings were present in spring and summer (Fig. 2a). Two or three pairs bred in the sanctuary each year (Chris Gee & Jo Ledington, *pers. comms*).

Brown teal (pāteke, *Anas chlorotis*) were released in Zealandia in November 2000 and April 2001 (18 birds) and New Zealand scaup (pāpango, *Aythya novaeseelandiae*) in April 2001 and March 2003 (7 birds); all birds of both species were sourced from captive stock (Miskelly & Powlesland 2013; Lynch 2019; Sheridan & Waldman 2020). Both species were consistently recorded in our counts from 2002 (Fig. 2). Brown teal counts declined significantly between each count block from a mean of 8.9 in 2002–05 to 2.5 in 2020–23 (Fig. 2c), while New Zealand scaup were stable at an average of 11.6 birds between 2002 and 2023 (Fig. 2d).

All three endemic duck species were regularly observed on both reservoirs.

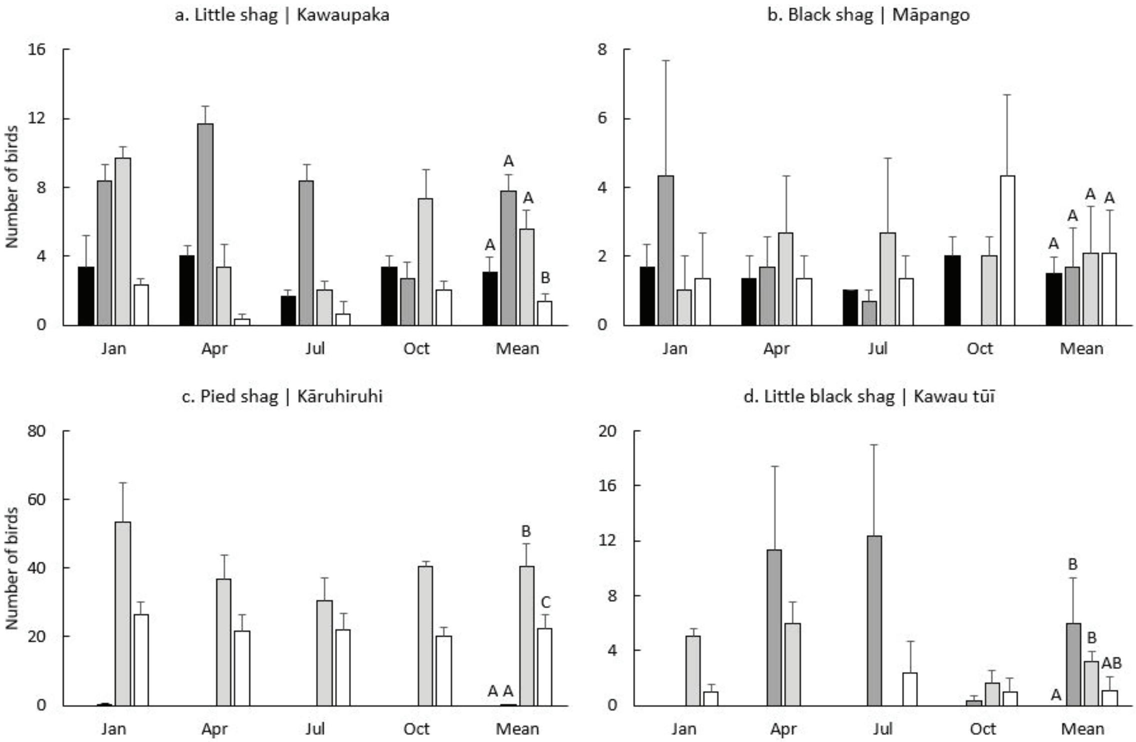

Figure 3. Shag (Phalacrocoracidae) counts in Zealandia sanctuary. Each bar represents the mean + standard error of the maximum count (lower + upper lake) for three consecutive years: 1995–98 (before the fence was built, black), 2002–05 (dark grey), 2013–16 (light grey), 2020–23 (white). Note that pied shag and little black shag were not present in 1995–98. Bars that share the same letter don't differ significantly (at P = 0.05).

Shags

Four species of shag used Zealandia (Fig. 3), with three species nesting there. Little shag (kawaupaka, *Microcarbo melanoleucos*) and black shag (māpunga, *Phalacrocorax carbo*) were both present in low numbers before the predator-proof fence was built (Fig. 3a & b), and were first recorded breeding in December 2003 and December 2008 respectively (Raewyn Empson, *pers. comm.*). Daytime counts of little shags peaked around 2014, when 19 nests were recorded (Chris Gee, *pers. comm.*). However, larger numbers have used the valley as a night-time roost, peaking at *c*. 100 birds in 1996 (Raewyn Empson, *pers. comm.*). Little shags still breed in the sanctuary; however, counts declined significantly to a mean of 1.3 per count session in 2020–23 (Fig. 3a). Little shags occasionally nest on the east side of the lake, in tree canopies below the track, where they are difficult to view and count from the track. Black shag counts have remained stable at a mean of 1.8 birds per count session throughout the 28 years (Fig. 3b). The majority of sightings for both species were on the lower reservoir (little shag 87.1%, black shag 89.4%).

The first pied shag (kāruhiruhi, *Phalacrocorax varius*) was recorded in the sanctuary during a count in January 2005 (the only individual of this species recorded during the 2002–05 count block; Fig. 3c). Pied shags started roosting in the sanctuary regularly from mid-2008, with the first breeding reported a year later (Raewyn Empson, *pers. comm.*). They were a common breeding species during the 2013–16 count block (mean 38.5 birds per count session). Pied shag counts declined significantly to a mean of 22.6 in 2020–23 (Fig. 3c). All nesting and almost all sightings of pied shags were on the lower reservoir, with three single birds only (0.4%) reported on the upper reservoir. The number of pied shags roosting in the lower reservoir was unaffected by the lowering of the water level and eradication of redfin perch in 2021 (Chris Gee, *pers. comm.*).

Little black shags (kawau tūī, *Phalacrocorax sulcirostris*) are not known to breed in the Wellington region. They mainly use Zealandia as a night-time roost during winter (Raewyn Empson, *pers. comm.*). Our daytime counts peaked during 2002–05; the subsequent decline in counts of little black shags

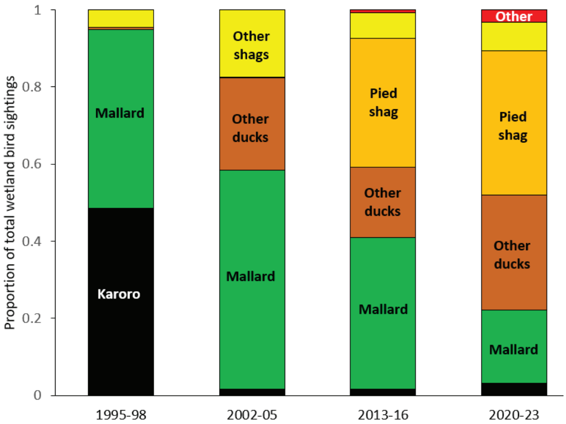

Figure 4. The composition of the Zealandia wetland bird community over 4 time periods, based on the proportional counts of each species or species group during counts undertaken in January, April, July, and October (counts averaged across seasons within each count block). The 1995–98 counts were undertaken before the predator-proof fence was built and the lower valley opened to the public. 'Other ducks' (across all four count blocks) included 55.0% New Zealand scaup / pāpango, 25.3% brown teal / pāteke, and 18.0% paradise shelduck / pūtangitangi, all of which are endemic, with brown teal and scaup released in the sanctuary. 'Other shags' were 51.5% little shag / kawaupaka, 26.7% little black shag / kawau tūī, 21.8% black shag / māpunga. 'Other' = other wetland bird species. Karoro = southern black-backed gull. Mallard / rakiraki was the only species among those graphed that was introduced to New Zealand.

through to 2020–23 was not statistically significant (Fig. 3d). Nearly all records were from the lower reservoir (98.1%).

Changes in the Zealandia wetland bird community over time

The wetland bird community in Zealandia has changed dramatically since the sanctuary was created (Fig. 4). During the initial (1995–98) count block, the community was dominated by karoro and mallards, with a few little shags and black shags (Fig. 4). Karoro became a negligible component of the wetland bird community in all subsequent count blocks, and the newly-colonised pied shag was by far the most common shag species in the last two count blocks (Fig. 4). The actual and proportional decline in mallards (the only non-native wetland bird species present) over time meant that the indigenous component of the wetland bird community in Zealandia has increased from 53.6% before the sanctuary was created, to 81.1% in 2020–23. The proportion of endemic wetland bird species (all of which were ducks, including two translocated species) increased from 0.5% to 30.4% over the same time period (Fig. 4).

DISCUSSION

The wetland bird community in Zealandia changed substantially following creation of the sanctuary. Originally dominated by southern black-backed gulls / karoro and non-native mallards, both of these species have become much scarcer, and native pied shags and three endemic duck species are now the most conspicuous components of the wetland bird community. These changes are similar in direction to those reported for the forest bird community in the sanctuary (Miskelly 2018), and have contributed to the primary restoration objective of restoring indigenous character in the valley (Lynch 2000; Campbell-Hunt 2002).

The most dramatic change in the Zealandia wetland bird community over the 28 years was the disappearance of large flocks of karoro following pest mammal eradication and creation of the sanctuary. There is no evidence that this decline was associated with a change in gull or rubbish management at the nearby Southern Landfill, and karoro remain abundant there, often with more than 1,000 birds present (Biz Bell, *pers. comm*.). Human use of the lower valley changed from almost nil when it was a water catchment area with restricted access, to a continuous stream of sanctuary members and paying visitors moving along the Lake Road that overlooks the lower reservoir. We suspect that the regular presence of people near the lake discouraged karoro from settling and bathing. Karoro have become over-abundant near metropolitan centres, largely as a result of poor waste management by humans, and are frequently the focus of management actions to reduce their numbers or discourage them from congregating (Fordham 1967, 1968; Galbraith *et al.* 2015; Miskelly 2022). It is ironic that one of the earliest consequences of the Zealandia Sanctuary being created was a significant and permanent decline in the numbers of a native bird species that used the valley, even if it was a species that few people value (it is one of only two native New Zealand bird species that currently has no legal protection; Miskelly 2014).

Unlike the gulls, mallard numbers appeared unaffected by creation of the sanctuary, and their numbers remained stable for at least 21 years. The marked decline in mallard numbers after 2016 did not appear to be directly linked to any management actions within the sanctuary, nor did it reflect any change within the Wellington region (including Horowhenua and Wairarapa), where mallard numbers were stable or increasing over the same period (Kavermann 2022). The decline occurred before redfin perch eradication was attempted in the lower reservoir, and there was no contemporaneous increase in the two endemic duck species that had been released between 2000 and 2003 (Fig. 2), and so the decline in mallards was unlikely to have been due to competition. It is possible that mallards were affected by trophic changes following the eradication of brown trout (*Salmo trutta*) from the upper reservoir in 2015 (Lynch 2019), although no link has been proposed or investigated.

While New Zealand scaup have had a stable population in Zealandia from soon after their release, counts of brown teal declined following a peak in 2002–05. A study undertaken in the sanctuary during 2013–14 estimated that there were 40–50 brown teal in the sanctuary, with most of the birds living along forested streams away from the lakes (Sheridan & Waldman 2020). During the same period, we recorded mean counts of only 5.3 brown teal on the lakes, which suggests that diurnal lake counts detect less than 13% of the brown teal present in the sanctuary, and may not have been a reliable index of the status of the species. It is unknown whether the ratio of lake-dwelling to forest-dwelling brown teal has changed over time; however, we suggest two factors that may have resulted in brown teal becoming more secretive in Zealandia over time. The first is the deaths of the founding birds, which were all captive-reared and so may have been more confiding than wild-reared birds. The second was the colonisation of the sanctuary by New Zealand falcons (kārearea, *Falco novaeseelandiae*) from 2009 (Miskelly 2018). A falcon attacking brown teal ducklings was reported to BDB on 25 June 2023. The presence of falcons may have led to brown teal roosting among vegetation, where they would not be visible from the public tracks used for the wetland bird surveys. We are therefore uncertain whether the declining counts of brown teal after 2005 are due to a population decline or a change in the birds' behaviour, or a combination of the two.

Pied shags were not known to breed in the Wellington region before 1996, when a colony was discovered at Makara Beach (Powlesland *et al.* 2008). They started breeding at Zealandia in 2009 (reported here) and on Mana Island in 2010 (Miskelly 2023). By 2023 there were at least seven colonies between the Pencarrow coast (east of Wellington Harbour entrance) and Kapiti coast (data from eBird, viewed 7 August 2023). This rapid colonisation and population expansion within the Wellington region, and the fact that five colonies have established at sites where mammalian predators are present, suggests that pied shags would likely have colonised Zealandia regardless of the predator management regime there. Unlike pied shags, both little shags and black shags were recorded using the two lakes during the 1995–98 counts, before the predator-proof fence was built. The fact that both species began breeding 4–9 years after fence construction suggests that this was a response to predator exclusion; however, we note that both species breed at numerous mainland sites in the absence of predator control. While all three shag species likely benefited from the absence of predatory mammals at their nest sites, this may not have been a necessary condition for them to establish breeding colonies in the sanctuary.

The eradication and subsequent exclusion of mammalian predators from Zealandia was a necessary requirement before brown teal were released there, as they are highly vulnerable to introduced predators (Parrish & Williams 2001; Williams 2001; O'Donnell *et al*. 2015). The absence of mammalian predators may also have allowed New Zealand scaup to establish and maintain a small, stable population in the valley. However, we suggest that the other changes in the wetland bird community reported here (the decline in gulls, and the large increase in shags) were driven by factors other than the absence of introduced mammals in the sanctuary.

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APPENDIX 1. Wetland bird species recorded from Zealandia Te Māra a Tāne between 1995 and 2023. BDB, CMM, and DMB are the authors' initials. OSNZ = Ornithological Society of New Zealand quarterly bird surveys as described in Methods. 'Zealandia' records are from records maintained by the Zealandia conservation team (Jo Ledington, *pers. comm.*). Many additional records and species from eBird were disregarded, as some visitors to Zealandia apparently used the site as a 'catch-all' location for additional species they recorded in the Wellington region, including at coastal sites.

Black swan (kakīānu, *Cygnus atratus*) – 1 from 13 February to 15 March 2016 (eBird), 1 from 8 February to 21 May 2017 (DMB, CMM, eBird) with 2 on 23 March and 26 May 2017 (eBird), 1 on 3 July 2020 (BDB).

Paradise shelduck (pūtangitangi, *Tadorna variegata*) – resident, breeding (see main section).

Grey teal (tētē-moroiti, *Anas gracilis*) – 2 on 26 June 2016 (eBird), 2 on 14 & 25 June 2017 (eBird), 3 on 12 October 2017 (BDB), 2 on 27 February 2022 (eBird), 2 on 6 June 2023 (eBird).

Brown teal (pāteke, *A. chlorotis*) – resident, breeding (see main section).

Mallard (rakiraki, *A. platyrhynchos*) – resident, breeding (see main section).

Grey duck (pārera, *A. superciliosa*) – 6 records of up to 4 birds by OSNZ teams 2002 to 2015.

Australasian shoveler (kuruwhengi, *Spatula rhynchotis*) – pair (ex-captivity) released November 2000 (did not persist).

New Zealand scaup (pāpango, *Aythya novaeseelandiae*) – resident, breeding (see main section).

New Zealand dabchick (weweia, *Poliocephalus rufopectus*) – 1 from 20 November 2014 to 28 May 2015 (authors, *pers. obs* and eBird), 1 on 2 January 2021 (eBird), 1 on 4 & 12 December 2021 (eBird), 1 from 25 July 2022 to 9 January 2023 (BDB and eBird), 1 from 6 to 17 March 2023 (eBird).

Pied stilt (poaka, *Himantopus himantopus*) – 1 on 29 July 2021 (eBird).

Spur-winged plover (*Vanellus miles*) – rare visitors (Zealandia).

Red-billed gull (tarāpunga, *Chroicocephalus novaehollandiae scopulinus*) – 1 on 10 July 1995 (OSNZ), 2 on 24 September 2019 (eBird), 2 on 29 July 2021 (eBird).

Southern black-backed gull (karoro, *Larus dominicanus*) – regularly present (see main section).

Little shag (kawaupaka, *Microcarbo melanoleucos*) – regularly present, breeding (see main section).

Black shag (māpunga, *Phalacrocorax carbo*) – regularly present, breeding (see main section).

Pied shag (kāruhiruhi, *P. varius*) – regularly present, breeding (see main section).

Little black shag (kawau tūī, *P. sulcirostris*) – regularly present (see main section).

Kōtuku (white heron, *Ardea alba*) – 1 in 2000 (Zealandia).

White-faced heron (matuku moana, *Egretta novaehollandiae*) – 1 in 2005 (Zealandia), 1 on 12 March 2013 (eBird), 1 on 2 February 2020 (eBird).

Royal spoonbill (kōtuku ngutupapa, *Platalea regia*) – 1 in October 2010 (Zealandia), 5 on 6 November 2012 (Zealandia), 1 on 20 September 2017 (BDB), 2 on 12 December 2021 (eBird).

Pūkeko (*Porphyrio melanotus*) – 1 during April to July 2012 (BDB), 1 to 5 from 2 to 11 February 2020 (eBird).

Australian coot (*Fulica atra*) – 2 on 13 November 2016 (eBird), 1 on 15 & 29 July 2021 (BDB & eBird), 2 on 31 March 2022 (eBird).

Sacred kingfisher (kōtare, *Todiramphus sancta*) – analysed as part of the forest bird community (Miskelly 2018).

Welcome swallow (warou, *Hirundo neoxena*) – analysed as part of the forest bird community (Miskelly 2018).

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An historical review of tree martin (*Petrochelidon nigricans*) records in New Zealand

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Abstract: Tree martins (*Petrochelidon nigricans*) are vagrants to New Zealand from Australia, with the first record in 1851. However, there is some doubt as to whether every tree martin historical record can be assigned to this species, with the now-established welcome swallow (*Hirundo neoxena*) a likely confusion species. Records of tree martins and other hirundines were examined against historical record criteria in order to establish an accurate picture of past tree martin vagrancy. Forty-eight relevant records (1851–1978) were collated and reviewed. It was considered that 16 records were probable or confirmed tree martins, 19 were possible tree martins, and just three were possible welcome swallows. The remaining ten records were classified as unidentifiable, with most of these lacking descriptions. Only four 19th century tree martin records should be verified. None of the many 1892–93 hirundine invasion records could be certainly assigned to any particular species. Considering the tree martin was more frequently recorded, it is perhaps surprising it is the less successful colonist of the two species.

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Keywords: tree martin, *Petrochelidon nigricans*, New Zealand, historical records, welcome swallow, *Hirundo neoxena*

INTRODUCTION

The most recent *Checklist of the birds of New Zealand* (Checklist Committee 2022) states that tree martins (*Petrochelidon nigricans*) are "Vagrant to New Zealand, both singly and in small flocks, mainly in autumn". The only dated 19th century record in the *Checklist* (op. cit.) is "May have nested at Oamaru around 1893 (Buller 1895; Oliver 1955)" and the earliest dated 20th century record is Featherston (1946).

However, some of these records may have referred to welcome swallows (*Hirundo neoxena*) (Anonymous 1884; Anonymous 1888; Hill 1897; Edgar 1966; Heather & Robertson 1996). Buller (1872–73, 1883, 1887–88, 1905–06) perpetuated this situation by only considering one hirundine species, the tree martin, as visiting New Zealand, though being well aware of other Australian hirundines such as the "Common Swallow (*Hirundo frontalis*)" = welcome swallow (Buller 1872–73).

The two hirundine species are somewhat similar and fast-flying. Tree martins can be identified by their white rump, whitish underparts and short tail, compared to the welcome swallow's longer forked

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tail and rufous throat and breast (Falla, Sibson & Turbott 1970). Juvenile welcome swallows are whiter underneath and have shorter tails. If seen well they should be easily separable; however, in past times the optics used for birdwatching were inadequate, and most observers did not possess any. (It was not until 1894 that the first effective binoculars – the Zeiss Feldstecher – became available [Moss 2004]). Even more recently, Heather (1956) said about a welcome swallow at Farewell Spit that "The swift irregularity of the bird's silent bat-like flight made binoculars virtually useless". Henderson (1964) also stated that "The (hirundine's) flight was so fast and erratic that although I kept the field glasses handy I never succeeded in viewing it through them". Accordingly, it could often be difficult to ascertain a hirundine's true identity just by sight. Specimens were also often collected in the 19th century to establish identity, and a few remain in museum collections.

Welcome swallows did not breed in New Zealand until the late 1950s (Michie 1959), with a few scattered records before then from the 1920s onwards (Checklist Committee 2022). Fairy martin (*Petrochelidon ariel*) is also a confusion species; however, the first New Zealand record was not until December 1978, when its distinctive nests were found in the Wairarapa (Bell 1984).

Ascertaining the hirundine species involved is also important in establishing specific vagrancy and potential colonisation patterns. The several hirundine species that may stray to New Zealand from Australia have different migratory and breeding behaviours (Higgins *et al.* 2006), and confirming which species have occurred, their frequency, and subsequent establishment (or not) can be important in biogeographical studies (Falla 1953; Fleming 1962; Trewick & Gibb 2010).

"Hicks Bay, Mahia, Cape Campbell, Collingwood, Wakapuaka, Blenheim, Mokihinui, Christchurch, Oamaru; Featherston May-Sept. 1946 (sight-record)" (Checklist Committee 1953). These localities are familiar to anyone who has read the tree martin account in Oliver (1930, 1955) or in any of the five *Checklists of the Birds of New Zealand* dating back to 1953 (Checklist Committee 1953, 1970, 1990, 2010, 2022). This introductory list of localities has been unchanged for nearly a century, but remains somewhat uninformative, as it mostly lacks dates or original references. The list was taken from Oliver (1930), with the Featherston record being added by Checklist Committee (1953). Buller (1872–73, 1887–88) was Oliver's (1930) only cited source. Rarity records should be dated at least to year to be verifiable (Harrop 2011), and so Oliver's (1930) records in particular were researched in order to provide missing dates and references.

In this paper, historical records of tree martins and other hirundines in New Zealand were examined against historic record criteria (Harrop 2011), in order to ascertain an accurate picture of past tree martin vagrancy.

METHODS

Records of tree martins and other hirundines were searched for in relevant publications, e.g. *Transactions and Proceedings of the New Zealand Institute*; Buller (1872–73, 1887–88, 1905–06); *Checklists of the birds of New Zealand* (op. cit.), the journals *Emu*, *New Zealand Bird Notes* and *Notornis*, and online Papers Past (2023). New Zealand, British and American museums with bird collections were also researched or contacted (see Acknowledgements). Birds New Zealand members were contacted via BirdingNZ.net for information. All unassessed (by the Birds New Zealand Rare Birds Committee [RBC] and Records Appraisal Committee [RAC]) tree martin records prior to 1979 were examined to see if they were verifiable according to historical record criteria (Harrop 2011).

Historical records should have as a minimum the species, date, location, and observer, with evidence of a specimen (including lost specimens that had been examined), photograph, or adequate description (Harrop 2011). Many historical tree martin records have not been verified, but have entered the literature through their incorporation into written works by various authorities (e.g. Buller 1905–06; Oliver 1930, 1955; Checklist Committee 1953). Some records have also never entered the ornithological literature for various reasons.

Each historical record is classified as either "unidentified hirundines", "possible welcome swallows / tree martins", "probable tree martins", or "confirmed tree martins". "Unidentified hirundines" do not have enough information to make an informed judgement; "possible" are those records which reference a species, but contain no further information (tree swallow, Australian martin and "marten" are considered to indicate tree martin; Australian swallow indicates welcome swallow in Australia [Higgins *et al.* 2006], but it also meant tree martin in New Zealand (e.g. Cook *in* Buller 1883; J.H.S. 1930]. Dall [Buller 1895] also used "Australian Swallows or Martins" not as an either/or term, but as a tree martin signifier); "probable" have indicative descriptions or are late 20th century records with observers who would be familiar with the now-established welcome swallow; and "confirmed" have good descriptions (with the white rump the definitive feature) and/or specimens.

RESULTS

Forty-eight relevant historical records were collated for the period 1851–1978 (Table 1). Table 2 lists the probable and confirmed records of tree martin after assessment.

Table 1. Distribution by decade of historic hirundine records (n = 47; excludes one undated record from Cape Campbell).

1850	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970
2	1	6	2	14	2	3	4	0	2	0	3	8

Table 2. Probable (P) or Confirmed (C) records of tree martins in New Zealand, 1851–1978.

Location	Date	Probable or Confirmed	Reference
Wakapuaka, Nelson	Summer 1851	P	Buller (1868)
Taupata, Nelson	14 March 1856	C	Buller (1868)
Opaoa River, Blenheim	9 June & July 1878	C	Buller (1878a)
Grovetown, Blenheim	April 1879	C	Buller (1883)
Morton Mains, Southland	October 1914	C	Anonymous (1914)
Featherston, Wairarapa	May, 9–10 Sept. 1946	C	Barton (1947)
Spring Creek, Blenheim	29 March 1947	C	Phillips (sic) (1947)
Otatara, Invercargill	Nov 1963 – Mar 1964	C	Henderson (1964)
Waitaki RM, Canterbury/Otago	June – July 1972	P	Edgar (1973)
Lake Waituna, Southland	January 1973	C	Edgar (1973)
Hicks Bay, Gisborne	25 Apr – 13 Jul 1974	C	Henley (1974)
Waipori, Lake Waihola, Otago	1975	P	Edgar (1975)
Rangitukia, Gisborne	9 April 1975	C	Edgar (1977)
Wainono Lagoon, Canterbury	June 1976	P	Edgar (1976); Pierce (1980)
Matata, Bay of Plenty	25 April 1977	C	Heather (1977); Edgar (1977, 1978)
Farewell Spit, Nelson	3 October 1978	P	Dennison & Robertson (1979)

Museum specimens

Of the New Zealand museums contacted, only the National Museum of New Zealand Te Papa Tongarewa, Wellington (Te Papa), possessed a New Zealand tree martin specimen (Te Papa OR. 014040). Museums without tree martin specimens included Kiwi North Museum, Whangarei (N. Brookland, *pers. comm.*), Auckland War Memorial Museum (AWMM. 2023), Nelson Provincial Museum (M. Davies, *pers. comm.*), Canterbury Museum, Christchurch (P. Scofield, *pers. comm.*) and Hokitika Museum, Westland (V. Bradley, *pers. comm.*).

The Southland Museum (SM), Invercargill, had one older welcome swallow specimen (SM 0000.5107; no provenance [np]) and a supposed tree martin egg (SM 85.393), labelled "South I." (K. Brett, *pers. comm.*). Otago Museum (OM) had one older welcome swallow specimen (OM AV1915; np) (E. Burns, *pers. comm.*). Whanganui Regional Museum (WRM) had two welcome swallow specimens: WRM TO. 121 (np) originally identified as a tree martin, and WRM TO. 122 (np) originally identified as a "Black North Island Robin" (T. Nugent-Lyne, *pers. comm.*). These were re-identified in the 1990s. Puke Ariki, New Plymouth (PANP), had one welcome swallow specimen (PANP A64.946 (np)) (M. Wells, *pers. comm.*).

A tree martin specimen (np) was in the New Zealand bird collection of Mr S. William Silver at the Manor House, Letcomb Regis, England, obtained prior to 1885 (Buller 1888). This was part of the collection of 252 birds sold by Buller to Silver in 1885 (Galbreath 1989; Bartle & Tennyson 2009). The Oxford University Museum of Natural History (OUMNH) acquired this specimen (OUMNH 09932) in 1906 (OUMNH 2023).

The Carnegie Museum of Natural History (CMNH) has a study skin from Buller's "third" collection (CMNH P24640), the specimens of which were collected between 1891-98 (Bartle & Tennyson 2009); it is a female with location given as New Zealand, but with no other data (Rogers

2022). Buller (1872–73, 1887–88, 1905–06) made no reference to any other tree martins being in his collection, besides the Grovetown (April 1879) specimen (Buller 1883) (now in the American Museum of Natural History (AMNH) (AMNH Skin 560834). However, he was constantly adding to his collection (Bartle & Tennyson 2009), and so would have included these on an *ad hoc* basis. It may have been collected during the 1892-93 hirundine invasion. Bartle & Tennyson (2009) stated that "1. Walter Buller did not label his specimens except for sale. He removed all collectors' labels. 2. None of the three Buller collections studied was adequately labelled. Specimens in the 1871 'First Collection' carried only numbered tags."

Probable or Confirmed (P/C) tree martin records (Table 1) (*Localities in Oliver [1930]).

(P) Wakapuaka*, Nelson; summer 1851: The first report of tree martins in New Zealand is that of F. Jollie, who "observed a flight of Swallows at Wakapuaka, in the vicinity of Nelson, and succeeded in shooting one" in the summer of 1851 (Buller 1868). Jollie's description led Buller to believe it was this species. The specimen's fate is unknown. As Buller apparently did not view the specimen it is classified as probable.

(C) Taupata, Nelson; 14 March 1856: A specimen shot by Mr Lea on 14 March 1856 at Taupata was identified by Buller (1868) as a tree martin. The specimen was placed in the OM, Dunedin (Buller 1872-73). The *Catalogue* (New Zealand Exhibition 1865) listed this bird as Hirundo (?) Swallow, shot by A.A.W. Lee (sic), so Buller appears to have examined it after this date. Hutton (1871) re-examined this bird and described it well in his *Catalogue of New Zealand birds*. The record can be considered confirmed on the basis of Buller's and Hutton's verification.

(C) Opaoa River, "Blenheim"* (i), Marlborough; 9 June and July 1878: Oliver (1930) apparently subsumed Buller's (1878a; 1878b; 1883) Opaoa River and Grovetown records into his "Blenheim" locality. J.R.W. Cook wrote to Buller (1878a) describing a martin ("more like the English House-Martin [(*Delichon urbicum*)] than the common Australian Martin", indicating that the bird had a prominent white rump) that he saw at the Opawa River (sic), two miles from Blenheim on 9 June 1878. Cook (Buller 1878b) saw it again a month later.

(C) Grovetown, "Blenheim"* (i), Marlborough; April (1879): Some confusion attends the year of this record as Buller (1883) firstly said he received this specimen "which I now exhibit (October 1883)" in "April last", which would be 1883. Later, in Buller (1887-88) he then stated he received the specimen in "April of the following year" (after Cook's 1878 sightings), which would be 1879. Buller (1887-88) also quoted directly from Cook's accompanying letter with the specimen, in which Cook states "Since writing to you last winter (=1878)", which suggests 1879. The year is further confused by Cook's statement in a letter (11th June) noting a paragraph in the Kaikoura Star concerning "Swallows" appearing at the same time as the Grovetown birds. The Kaikoura Star was not published until November 1880; 1879 is presumed to be the correct year in this paper until further information comes to light.

An adult female tree martin (of six or seven birds) was shot by Mr Cheeseman in April 1879, given to J.R.W. Cook and then to Buller (Buller 1883). It was subsequently sold to Rothschild (Bartle & Tennyson 2009) and is now in the AMNH (AMNH Skin 560834; P. Scofield, *pers. comm.*; Trombone 2013). The specimen has its collector (J.W. Cook) and locality (Blenheim, South I., New Zealand) written on the Rothschild label and given in the catalogue, and so it is most likely to be this record. The identification was confirmed by P. Sweet, Collection Manager, Department of Ornithology, AMNH (*pers. comm.*). The sternum was placed in Prof. Newton's collection at Cambridge University (Buller 1883). Bartle & Tennyson (2009) contradicted the identification and said that this bird was a welcome swallow, "the third New Zealand record", but without accompanying clarification.

(C) Morton Mains, east of Invercargill, Southland; October 1914: A tree martin collected in October 1914 was placed in the Invercargill Museum (SM), after identification by the Curator Robert Gibb (Anonymous 1914). The specimen has since disappeared (K. Brett, *pers. comm.*).

(C) Featherston, Wairarapa; May & 9–10 September 1946: A tree martin was seen by Barton (1947) at Wharetoto, Featherston on 9–10 September. It had been present since May. Barton described the black upperparts, black tail tip, forehead patch and short tail.

(C) Spring Creek, Grovetown, Blenheim, Marlborough; 29 March 1947: one of six tree martins in March 1947 (Phillips [sic.] 1947) was collected by S. G. Connolly and is now in Te Papa (Te Papa OR.014040). Connolly also stated that he had seen this species "on at least four different occasions in the last ten years". This record has not entered the New Zealand literature, probably because the note

was published in the Australian journal *Emu*.
(C) Otatara, Invercargill, Southland; November 1963 – March 1964: A supposed welcome swallow was described by Henderson (1964). Edgar (1966) thought that this bird was a tree martin instead, as it had a pale rump and brownish-black upperparts.

(P) Waitaki River mouth, Canterbury / Otago; June – July 1972: Reports of five tree martins in mid-June and two in mid-July at Waitaki River mouth by R. Wallis (Edgar 1973).

(C) Lake Waituna, Southland; January 1973: A hirundine with white rump and no long outer tail feathers at L. Waituna was seen by Dr L. Franklin per M.L. Barlow (Edgar 1973).

(C) Karakatuwhero River mouth, Hicks Bay, Gisborne; 25 April – 13 July 1974: Thirty-five tree martins were in a loose flock here in autumn and winter 1974 (Henley 1974). These birds were well-described, with "the distinguishing features of greyish-white rump….and chestnut-brown forehead" noted (Henley 1974).

(P) Waipori, Lake Waihola, Otago; 1975: Tree martins were reported at Waipori sometime during 1975 by M.L. Falconer (Edgar 1975).

(C) Rangitukia, Gisborne; 9 April 1975: Twenty tree martins with welcome swallows seen by J.C. Henley (Edgar 1977), who had previously seen them at Hick's Bay (Henley 1974).

(P) Wainono Lagoon, Canterbury; June 1976: One tree martin reported by R.J. Pierce (Edgar 1976; Pierce 1980).

(C) Matata, Tarawera estuary, Bay of Plenty; 25 April 1977: A tree martin with *c.* 40 welcome swallows on 25 April, seen by P.C. Latham [PCL] (Edgar 1977; Heather 1977). The white rump was obvious, along with other plumage and behavioural differences (Heather 1977). Edgar (1978) also referred to a tree martin being seen by PCL in January at the same locality with 40 welcome swallows, which appears to be in error.

(P) Farewell Spit, Nelson; October 1978: A tree martin at the base of the Spit (Dennison & Robertson 1979).

Possible tree martin records (*Localities in Oliver [1930]).
River Avon, Christchurch*, Canterbury; 1861: Mr J.D. Enys saw "Tree Swallow", "skimming over the Avon in Christchurch" in 1861 (Buller 1883; Potts 1884-85).

Maketu, Bay of Plenty; September 1876: A correspondent wrote that the "Australian swallow …. is now to be found in our midst…. the only conclusion…. is that they have been blown here in some of the strong westerly gales from Australia" (Anonymous 1876).

Auckland; <1878: a pair of "tree swallows" were shot at Auckland "some time ago" (pre-1878) (Anonymous 1878).

Opaoa River, "Blenheim"* (ii), Marlborough; 16 February 1879: Cook (Buller 1883) described a martin with a dingy white rump (but he also mentioned chestnut on the breast, which calls into question the species).

Moeraki, Otago; March & April 1881: Bills (Anonymous 1881a) and M'Kenzie (Anonymous 1881b) saw five or six "Australian swallows" at Moeraki Point in March (Anonymous 1882) and April 1881. A later correspondent called these "welcome swallows", but without explanation (Anonymous 1884). Buller (1883) referred to these as tree martins.

"Collingwood"* = New Zealand; 1892–93 (apparently referred to as Collingwood by Oliver [1930] because Buller's [1895] correspondent J. Dall (a well-known plant and animal collector [Godley 1985]) lived there): Dall stated that large numbers of "Australian Swallows or Martins" visited New Zealand during spring, summer and autumn 1892–93 (Buller 1895, 1905–06). Buller (1905–06) did not doubt that these were all tree martins.

Farewell Spit, Nelson; spring 1892: Flocks of two or three dozen "Australian Swallows or Martins" (implied) were at Cape Farewell (sic) in spring 1892 (Buller 1895, 1905–06).

Oamaru*, Otago; 1893: a pair of "Australian Swallows or Martins" (implied) bred at a mill near Oamaru in 1893 (Buller 1895, 1905–06). (The original source (*Canterbury Times*) was not seen).

New Brighton, Christchurch; March–May 1893: A flock of a dozen swallows or "Martens" were seen by Messrs Warner, Curtis and Murphy (Anonymous 1893c, Anonymous 1893d).

Bay of Plenty; May 1893: Three "Martens" were seen "in this neighbourhood" (Anonymous 1893e).
Collingwood, Nelson; June 1893: A number of "Australian martins" were seen about the township, but quickly moved on (Anonymous 1893f).

Westport, Westland; 1894-96: "It *(*tree swallow*)* has also been seen at Westport, in small numbers, for several years in succession" (Townsend *in* Buller 1905-06).

Mokihinui*, Buller District, Westland; 1896: Two "Australian Tree-Swallows" were seen at Mokihinui in *c*. 1896, by W. Townsend (Buller 1905–06).

Matakawa, "Hicks Bay* (i)", Gisborne; June 1897: Mr Henderson saw martins around his homestead in the first week of June, after seeing (welcome) swallows in April 1897, apparently able to differentiate between the two hirundine species (Hill 1897). Oliver (1930) did not separate the April and June sightings, apparently of two different hirundine species.

Cape Foulwind, Westland; 1908: Drummond (1908) in reply to a correspondent said that "you are probably right in assuming that the bird seen near Cape Foulwind was an Australian Swallow. A fairly large number of these birds have wandered from the Commonwealth to this dominion", which implied Drummond was referring to tree martins.

Kennington, Invercargill, Southland; *c.* June 1911: An "Australian Swallow" was reported at Kennington in *c*. June 1911 (Anonymous 1911).

Awanui, Northland; 23 – 28 July 1914: An "Australian Swallow" was seen by J. H. Smith at Awanui, skimming the water (Drummond 1914).

Manakauaia, Westland; December 1963 – January 1964: A tree martin reported by P. Grant (1964).

Raoul Island, Kermadec Islands; 14 September 1966: Unconfirmed records of a tree martin seen on 14 September, and another in an exhausted state captured about this time by T. Blake (Merton 1970).

Possible welcome swallow records (*Localities in Oliver [1930)].

Matakawa, "Hicks Bay* (ii)," Gisborne; April 1897: Mr Henderson saw swallows with russet-brown on the back (presumably the breast) around his homestead in April (Hill 1897).

Kaitaia, Northland; 1920's: Michie (1959) had a welcome swallow under observation for more than a week. The locality was not stated, but Herekino was "about fifteen miles from here", which implied it was around Kaitaia.
Herekino, Northland; 1920's: One was shot about the same time as the above record, and the wings displayed in the local "Northlander" newspaper office window (Michie 1959).

Unidentifiable hirundine records (*Localities in Oliver [1930]).

Nelson; <1875: "Swallows" were seen several times in Nelson before 1875 according to Sir David Munro (Anonymous 1874; Buller 1883).

Kaikoura, Canterbury; April 1879: Two "Swallows" were seen at Kaikoura, about the same time as the Grovetown birds (Cook citing the *Kaikoura Star* in Buller [1883]).

Timaru, Canterbury; 1888: W.W. Smith recorded hirundines in the neighbourhood of Timaru in 1888 (Thomson 1922). Thomson confused the tree martin with the welcome swallow (his account listed Buller's early tree martin records under "Australian Swallow (*Hirundo neoxena*)", and so it is uncertain which species was being referred to.

Canterbury; 1893: A flock of swallows appeared in Canterbury, and some were shot (Anonymous 1893a).

Waipaua, Nelson; *c*. April 1893: Swallows were seen here (Anonymous 1893b).

Mahia Peninsula*, Gisborne; August 1893: H. Guthrie-Smith saw "some birds like Martins or Swallows" in August 1893, which had been present for some weeks (Buller 1895, 1905-06). The tails were not forked, as far as he could tell.

New Brighton, Christchurch; 1901: Numbers of hirundines appeared around New Brighton, Christchurch (Thomson 1922).

Whangarei, Northland; undated <1922: Unconfirmed hirundines were reported to Thomson (1922).

Auckland; undated <1922: Unconfirmed hirundines were reported to Thomson (1922).

Cape Campbell*, Marlborough; undated <1930: Listed in Oliver (1930, 1955), but no further information has been found. Lighthouse Keeper A. Hansen was active here in the late 19th century, and his annual bird returns (Hansen 1891) have been examined; but tree martin was not listed. This record may be in error, as Oliver (1930) refers to Cape Farewell in an introductory paragraph, but then does not list it in his localities.

Accepted and recent unsubmitted records

There are also 22 recent (1960–2022) RBC/RAC accepted records of tree martin (Table 3). Records were from both main islands, but with a strong

Table 3. Rare Birds Committee (RBC) and Records Appraisal Committee (RAC) accepted records of tree martins in New Zealand (1960–2022).

Location	Date	Reference
Farewell Spit, Nelson	January 1960	Wright (1960)
The Snares	February 1969	Warham & Keely (1969)
Punakaiki RM, Westland	June 1977	Miskelly *et al.* (2021)
Miranda, South Auckland	February 1979	Checklist Committee (1990)
Vernon Lagoons, Marlborough	April 1980	Checklist Committee (1990)
Nelson Haven, Nelson	November 1981	Birds New Zealand (2023)
Lake Holm Farm, Otago	December 1981 – March 1984	Nevill (1984)
The Snares	August – October 1982	Miskelly *et al.* (2001)
Nelson Haven, Nelson*	November 1982	Fennell (1983)
Eglinton Valley, Fiordland	October 1983	Morrison & Morrison (1985)
The Snares	February 1984	Miskelly *et al.* (2001)
Farewell Spit, Nelson	January 1988	Checklist Committee (1990)
Chatham Island	November 1988	Miskelly *et al.* (2006)
Pukete, Hamilton	February 1992	Medway (2000)
Torrent Bay, Nelson	December 1999	Scofield (2008)
Lake Ohakuri, Waikato	November 2004	Scofield (2008)
The Snares	December 2014	Miskelly *et al.* (2017)
The Snares	March 2015	Miskelly *et al.* (2017)
Bromley, Canterbury	February 2017	Miskelly *et al.* (2019)
Farewell Spit, Nelson	December 2019	Miskelly *et al.* (2021)
Lake Ellesmere / Te Waihora, Canterbury	February 2020	Miskelly *et al.* (2021)
Wainono Lagoon, Canterbury	October 2020	Miskelly *et al.* (2021)

*The November 1983 record from Nelson Haven (Checklist Committee 1990; 2010; 2022) is erroneous (C. Miskelly *pers. comm.*).

Table 4. Unsubmitted records for tree martin in New Zealand, post-1979.

Location	Date	Reference
Waipori, Otago	13 March 1984	OSNZ OtagoDATA (2023)
Lake Holm Farm, Otago	March 1986	Gaze (1987)
Lake Holm Farm, Otago	20 April – 14 May 1986	Nevill (2023)
Farewell Spit, Nelson	December 1990 – January 1991	O'Donnell & West (1994)
Farewell Spit, Nelson	December 1991 – January 1992	O'Donnell & West (1994)
Lake Holm Farm, Otago	12–13 December 1996	O'Donnell & West (2001)
Lake Holm Farm, Otago	17 January 1997	O'Donnell & West (2001)
Lake Waikare, Waikato	22 December 2006	Linderström (2007)
Little Barrier Island	February 2013	Berg (2013)
Wairau Lagoons, Blenheim	9 April 2017	Leask & Leask (2017)

South Island bias. There were no records of tree martin from Stewart Island or north of Miranda, South Auckland. The Chatham Islands and Snares had one and three records respectively. Ten unsubmitted records since 1979 are also listed for completeness (Table 4).

Historical record assessments

This review of historical records indicated that 32 (66%) of the 48 records could not be confidently assigned to any hirundine species, as they lacked specimens or adequate descriptions.

Several specimens were obtained, but currently only the whereabouts of the Grovetown, Blenheim (1879) (AMNH) and Spring Creek, Blenheim (1947) (Te Papa) specimens are known. The Wakapuaka (1851), Taupata (1856) (OM) and Morton Mains (1914) (SM) specimens have disappeared. Undated specimens in the OUMNH and the CMNH were probably obtained in New Zealand by Buller in the late 19th century; however, they lack provenances and do not contribute further to this assessment. Unconfirmed museum records include a supposed South Island tree martin egg in the SM, and a WRM welcome swallow specimen (np) originally identified as a tree martin.

Of the sight records only Opaoa River (1878), Featherston (1946), Otatara (1963) and the eight records between 1972–78 could be determined as either probable or confirmed tree martins.

Christchurch (1861), Maketu (1876), Auckland (<1878), Opaoa River (1879), Moeraki (1881), "Collingwood" (=New Zealand invasion 1892-93), Farewell Spit (1892), Oamaru, New Brighton, Bay of Plenty, Collingwood (all 1893), Westport (1894-96), Mokihinui (1896), "Hick's Bay (i)" (June 1897), Cape Foulwind (1908), Kennington (1911), Awanui (1914), Manakauaia (1963–64) and Raoul Island (1966) were classified as possible tree martins.

"Hick's Bay (ii)" (April 1897), Kaitaia (1920s) and Herekino (1920s) were assessed as possible welcome swallows. The remaining ten records were considered unidentifiable hirundines.

The localities in Oliver (1930, 1955) which have continued to be listed in the Checklists (op. cit.) ever since can now be mostly dated and referenced (see Results). Some of Oliver's localities referred to two or three separate records i.e. "Blenheim" and "Hick's Bay", and "Collingwood" encompassed most of New Zealand. Only the Wakapuaka (1851) and "Blenheim (i)" (= Opaoa River 1878 & Grovetown 1879) records were of probable or confirmed tree martins.

Of the others, Christchurch (1861), "Blenheim (ii)" (= Opaoa River 1879), Oamaru (1892), "Collingwood" (= the New Zealand-wide hirundine invasion of 1892–93), Mokihinui (1896) and "Hicks Bay (i)" (June 1897) were of possible tree martins; "Hicks Bay (ii)" (April 1897) were of possible welcome swallows. Mahia (1893) and Cape Campbell (= Farewell Spit? <1930) were of unidentifiable hirundines.

This review has resulted in a reduction of acceptable tree martin records from 50 (Doyle 2013 [updated 2017]) to a current 39 records (this review; Birds New Zealand 2023).

An assessment of probable and confirmed tree martin arrival dates between 1851 and 2022 indicates that tree martin is as likely to arrive in any season of the year, rather than "mainly in autumn" contra Checklist Committee (2022) (Table 5). A chi-square test on the summed records in each season (summer = 14, autumn = 9, winter = 5, spring = 9) indicates that the difference between each season is not statistically significant ($\chi^2 = 3.556$, d.f. = 3, NS).

Table 5. Month of first sighting for each dated probable and confirmed tree martin record in New Zealand, 1851–2022 (n = 36).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of records	3	6	3	5	1	4	0	1	0	4	5	4

DISCUSSION

Hirundines have a distinctive flight and foraging behaviour, and are easily recognised as such, even by non-birdwatchers. All the reviewed historical records are therefore considered to refer to this family. No hirundines were resident in New Zealand before the 1950s, and so their appearance would have drawn some attention. The most likely source of New Zealand hirundines is Australia, where there are four native species (including white-backed swallow [*Cheramoeca leucosternus*], which has never been reported from New Zealand) and two migrant species, of which barn swallow (*Hirundo rustica*) might conceivably also straggle here (barn swallow is the champion wanderer – it has been recorded more widely as a vagrant than any other bird [Lees & Gilroy 2021]).

Gill (2000) discussed the holdings of New Zealand museums, with 112,000 registered bird specimens. Given this large number of specimens and the propensity of 19th century collectors to shoot anything interesting, it is surprising that only one tree martin specimen is extant in New Zealand museums, and this from the 20th century.

In some museums provenance was an issue, with hirundine specimens being without data, and/or re-identified, also without any data. Rasmussen & Prys-Jones (2003) discussed these issues in detail, but also suggest that data-less specimens may yield valuable information. Bartle & Tennyson (2009) for instance, found that Buller used distinctive labels on some of his specimens, and this assisted in identifying them. More tree martin specimens may be in overseas museums, especially in the United Kingdom. Written records of accessions may be the only way to verify some specimens.

A newspaper article by J.H.S. (1930) discussed the Haerenoa, or Go-as-you-please, aka Australian swallow. The writer referred to it as being first seen in small flocks in the Nelson district in 1851, indicating the writer was referring to the tree martin. The author stated Māori were aware of the species, had named it Haerenoa, and had seen it 50 years earlier. Many specimens had been seen or captured. The species had a steel blue body with a chestnut head, and lays pink eggs. Curiously the description fits fairy martin or even welcome swallow rather more than tree martin. The author appears to have had extensive knowledge of the "Australian Swallow". The article indicates that Australian hirundines of one or perhaps two species were well-known and even common in some places. Drummond (1908) also said much the same thing. This knowledge did not enter the bird literature then or subsequently. Newspaper accounts also reported widespread hirundine occurrences, but lacked descriptive details as to which species had actually been seen. The accounts are still useful in indicating the frequency and location of hirundine sightings, albeit unconfirmed as to species..

Out of the 48 historical records, only 16 should now be accepted as probable or confirmed tree martins. There are also a large number of possible records, which rely on the name that the observer used for their specific attribution. In cases where tree-swallow or martin are used tree martin is obviously the species meant, but the usage of Australian Swallow is more ambiguous. It appears that in New Zealand this term also referred to the tree martin. This affects the number of acceptable historical records, as only four 19th century records should be considered as probable or confirmed. Even the many records concerning the hirundine invasion of 1892-93 lack details confirming the species involved.

Welcome swallows were likely also visitors during the 19th century, but only suggestions of 19th century vagrancy are museum specimens (without provenances), a tree martin re-identified as a welcome swallow, and possible sight records in 1881 and 1897.

The tree martin and welcome swallow accounts in the next Checklist should therefore be amended to reflect this paper's findings. The possible and unconfirmed records could be appended (as they still indicate hirundine occurrence), to fill out the broader picture of Australian hirundines visiting, and one species eventually colonising, New Zealand.

Further research should be conducted in local and overseas museums to ascertain if there are any other New Zealand tree martin and welcome swallow specimens, with provenances. Older sight records should be submitted to the RAC with supporting descriptions, especially those from before the 1980s, to complete the database.

This review has uncovered many previously unknown records and shown the value of museum specimens and the "grey" literature in researching and verifying historical records. Although there were fewer verifiable tree martin records than previously thought, it is still apparent that hirundines arrived on frequent occasions from Australia during the 19th and 20th centuries. Why the tree martin eventually became the less successful colonist is a question that remains to be answered.

The first five records

Guidance for rarities committees suggests that for national rarities "the first (or preferably the first five) records should be published in detail in a national journal" (AERC. 1996). The first five tree martin records, based on this paper's assessments, would be:

1. Wakapuaka, Nelson; summer 1851 (New Zealand Exhibition 1865; Buller 1868).
2. Taupata, Golden Bay, Nelson; 14 March 1856 (Buller 1868, 1873; Hutton 1871).
3. Opaoa River, Blenheim, Marlborough; 9 June and July 1878 (Buller 1878a, b).
4. Grovetown, Blenheim, Marlborough; April 1879 (Buller 1883).
5. Morton Mains, east of Invercargill, Southland; October 1914 (Anonymous 1914).

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SHORT NOTE

Observations of birds on Niue, South Pacific (2014 & 2022), with a new locality record for brown booby (*Sula leucogaster*) and sooty tern (*Onychoprion fuscatus*)

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Observations of birds on Niue, South Pacific, commenced with the publication of a comprehensive checklist in *Notornis* by Wodzicki (1971). Other reports, including checklists by Child (1982), Gibb *et al.* (1989), and Powlesland *et al.* (2000). Child (1982) reported that the fauna of living birds is 28 species, and Powlesland *et al.* (2000) confirmed that the living bird fauna comprises 28 species, of which 18 were seen during their study.

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The National Museum of New Zealand published a report on the birdlife of Niue (Kinsky & Yaldwin 1981), with specific reviews on the status of the white-tailed tropic bird (*Phaethon lepturus*) and Pacific golden plover (*Pluvialis fulva*). Powlesland *et al.* (2006) reviewed the status of birds and rodents on Niue following the destructive Cyclone Heta in 2004. These authors also reviewed whether a decline of the Pacific pigeon (*Ducula pacifica*) population during 1994–2004 was attributed to Cyclone Heta or was caused by excessive hunting by people (Powlesland *et al.* 2008). More recently, Butler *et al.* (2012) comprehensively reviewed the status of birds, peka (Tongan flying fox, *Pteropus tonganus*), and reptiles in a report to the Pacific Regional Environment Programme and the Niue Government in 2012.

Niue is an elevated, mostly flat atoll, 26,100 ha in area, in the south-central Pacific Ocean (19.1°S, 169.9°W). It is 430 km east of Neiafu, Tonga, 1,070 km west of Rarotonga, Cook Islands, 600 km south-east of Apia, Samoa, and 2,350 km north-east of East Cape, New Zealand. The elevation of Niue is mostly 20–60 m a.s.l., with a maximum altitude of 69 m. a.s.l. Much of the shoreline is edged with steep rocky cliffs above a narrow wave-swept reef.

Short visits to Niue were made by Ingrid Hutzler (IH) in 2014 (9–17 May), and by Ian Armitage (IA) in 2022 (5–11 November). These visits, however short, enabled reliable observations to be made on this remote tropical island that is not often visited by observers of birds. This short note summarises records made by the authors and adds to the knowledge documented in earlier publications.

Most observations were made at spot positions and during walking counts of between 5- and 60-minutes duration through forests, bush gardens, villages, and on coastal reef habitats, and by viewing birds over reefs and the sea from coastal cliffs. Other counts on land were made whilst travelling slowly by car and by bicycle. Observations were also made by IA during one early morning offshore (pelagic) trip. Birds were observed using binoculars (10 x 42) and by watching without optical aids.

Records of the time for counts are a measure of the effort involved in making observations. Counts by IH were made for 940 minutes (coastal & sea sites 630 minutes, land sites 310 minutes). Counts by IA were made for 660 minutes (coastal & sea sites 250 minutes, land sites 410 minutes). No attempt has been made to separate the time spent observing each species.

Listing of bird species here (Table 1) follows the arrangement of orders shown in the *Checklist of the Birds of New Zealand (5th Edition)*, (Checklist Committee 2022). For some species the taxonomic nomenclature also follows the 2022 checklist, for others the taxonomic nomenclature used by Powlesland *et al.* (2000) is applied. Most localities are the names of Niuean villages.

We can confirm from our observations (Table 1) that the most common birds reported previously continue to be present on Niue. IH observed 18 species, IA observed 16 species.

Four brown booby (*Sula leucogaster*), probably adults, were observed by IH flying above the sea near the coastline of Tamakautoga village. Of these, three were near Ana'ana Point (12 May 2014), and one was near Matavai Resort (14 May 2014). Both observations were in mid-morning and by using binoculars.

A pair of adult sooty terns (*Onychoprion fuscatus*) were observed by IA at Makefu Village in the early morning of 10 November 2022. The birds were observed for 4–5 minutes by eye and using binoculars at a range of 30–50 metres. Both birds were flying slowly, even hovering at times, over scrubby vegetation on the edge of a cliff.

In comparing the bird fauna on Niue with four other South Pacific Island groups Gibb *et al.* (1989) reports that the brown booby and sooty tern occur on Tonga, Samoa, southern Cook Islands, and Fiji but not on Niue. Observations reported by the authors are the first published records of brown booby and sooty tern on Niue.

Disappointingly, one species the authors did not observe was the blue-crowned lorikeet (*Vini australis*). Powlesland *et al.* (2000) recorded this species only occasionally in 1994–95. Child (1982) noted that "the locals believe them to be in decline". This attractive species might continue to be present on Niue but probably in low numbers.

Numbers of birds of each species were recorded in the villages or other localities where they were observed. For sites that were visited more than once, only the highest number of individuals (of each species) was recorded.

Comparison of observations made in 2014 and 2022 (Table 1) suggest that the purple-capped fruit dove (*Ptilinopus porphyraceus*), banded rail (*Gallirallus philippensis*), white-tailed tropic bird, and reef heron (*Egretta sacra*) were less numerous in 2022 than in 2014 (Butler *et al.* 2012). This might be a seasonal effect, or a locality effect (more or less sampling effort in different localities between 2014 and 2022), or it might reflect a real decline in populations for these species from 2014. In the short time available the authors were unable to study this surprising finding that deserves further examination.

Feral chickens (*Gallus gallus*) are not reported here but are widespread and common in most localities. This species continues to be the only introduced bird on Niue.

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Table 1. Records of observations of birds on Niue made in May 2014 (IH – Ingrid Hutzler) and November 2022 (IA – Ian Armitage).

Species	May 2014 (IH)	Nov 2022 (IA)	Comments
Pacific pigeon (*Ducula pacifica*)	37 (28 Vinivini Track in Huvalu Forest, 9 Fue)	10 (3 Makefu, 3 Hikutavake, 2 Hakupu, 2 Vinivini Track in Huvalu Forest)	Common in forested habitats; more often heard than seen; the counts are conservative & likely underestimate true numbers present
Purple-capped fruit dove (*Ptilinopus porphyraceus*)	58 (42 Vinivini Track in Huvalu Forest, 12 Fue, 3 Alofi, 1 Tamakautoga)	6 (6 Makefu)	A strikingly attractive species, mostly seen & heard in forested sites
Long-tailed cuckoo (*Eudynamys taitensis*)	1 (1 Hakupu)	-	One bird seen flying across a road
White-rumped swiftlet (*Aerodramus spodiopygius*)	4 (4 Vinivini Track in Huvalu Forest)	13 (8 Makefu, 5 Lakepa)	Distribution is patchy; birds were observed in small flocks
Banded rail (*Gallirallus philippensis*)	37 (11 Hanan Airport, 5 Hakupu, 5 Hikutavake, 4 Alofi, 4 Liku, 3 Mutalau, 3 Tamakautoga, 1 Namukulu, 1 Vinivini Track in Huvalu Forest)	3 (1 Niue Foou Hospital Alofi, 1 Toi, 1 Tuapa)	Mostly observed running across roads to and from dense fern vegetation
South-west Pacific swamphen (*Porphyrio melanotus*)	3 (3 Hanan Airport)	1 (1 near Alofi)	Birds tend to avoid open sites, preferring cover
Pacific golden plover (*Pluvialis fulva*)	40 (16 Alofi, 9 Liku, 6 Mutalau, 4 Makefu, 4 Namukulu, 1 Hakupu,)	99+ (57+ Hanan Airport runway & taxiway on 11/11/22, 8 Makefu, 7 Tuapa, 7 Liku, 7 Toi, 5 Veli, 3 Alofi, 3 Hakupu, 2 Hikutavake).	Common & widely distributed in November, mostly on open grassy spaces in villages; the counts at the airport are conservative & underestimate true numbers present
Wandering tattler (*Tringa incana*)	2 (1 Lakepa, 1 Tamakautoga)	4 (4 Makefu)	Flying along and/or resting/feeding on reefs
Sanderling (*Calidris alba*)	2 (2 Namukulu)	-	Feeding on grassy sites & reefs
Brown noddy (*Anous stolidus*)	48 (20 Alofi, 15 Tamakautoga, 7 Vinivini Track in Huvalu Forest, 3 Fue, 3 Lakepa)	33 (16 Makefu, 8 Lakepa, 4 Liku, 1 Toi, 2 Vinivini Track in Huvalu Forest, 2 at sea near Alofi)	Usually single birds, or in pairs flying between forests & the sea
White tern (*Gygis alba*)	291 (150 Tamakautoga, 101 Alofi, 24 Vinivini Track in Huvalu Forest, 6 Fue, 6 Mutalau, 4 Lakepa)	66 (44 Makefu, 8 Veli, 4 Alofi, 4 Vinivini Track in Huvalu Forest, 4 at sea near Avatele, 2 Tuapa)	Common & widespread, often in pairs or up to 8, flying between forests & the sea. Birds were often seen flying inland carrying small fish in the bill; the counts at Alofi, Tamakautoga & Makefu are conservative & underestimate true numbers present
Sooty tern (*Onychoprion fuscatus*)	-	2 (2 Makefu [near Anaiki Motel])	1 adult pair observed for 4–5 minutes on 10 November 2022 flying above a forested cliff edge

Table 1. Records of observations of birds on Niue made in May 2014 (IH – Ingrid Hutzler) and November 2022 (IA – Ian Armitage).

Species	**May 2014 (IH)**	**Nov 2022 (IA)**	**Comments**
White-tailed tropicbird (*Phaethon lepturus*)	25 (15 Vinivini Track in Huvalu Forest, 4 Fue, 3 Alofi, 1 Lakepa, 1 Mutalau, 1 Tamakautoga)	3 (2 Makefu, 1 Veli, 1 Vinivini Track in Huvalu Forest)	Mostly single birds were observed flying from the sea or within & near Huvalu Forest
Great frigatebird (*Fregata minor*)	7 (2 Hanan Airport, 2 Hakupu, 2 Uani, 1 Tamakautoga)	3 (1 Makefu, 1 Liku, 1 Veli)	The birds were in flight (soaring) over the sea & land
Brown Booby (*Sula leucogaster*)	4 (4 Tamakautoga)	-	Birds were over the sea
Reef heron (*Egretta sacra*) - grey	7 (2 Avatele, 2 Mutalau, 1 Hakupu, 1 Namukulu, 1 Tamakautoga)	7 (2 Alofi, 3 Makefu, 1 Hakupu, 1 Vaiea)	Birds were seen singly on reefs & in village gardens
Reef heron (*Egretta sacra*) - white	15 (6 Avatele, 3 Hakupu, 2 Alofi, 2 Lakepa, 2 Tamakautoga)	-	Observed on reefs & at inland habitats
Barn owl (*Tyto alba*)	-	1 (1 Makefu)	One bird seen flying amongst trees & houses on evening of 5 November 2022
Polynesian triller (*Lalage maculosa*)	51 (31 Vinivini Track in Huvalu Forest, 16 Fue, 4 Hanan Airport)	18 (5 Alofi, 7 Hakupu, 2 Hikutavake, 2 Makefu, 2 Tuapa)	Mostly heard & seen in village & forested sites having a scattered or dense tree cover
Polynesian starling (*Aplonis tabuensis*)	14 (12 Vinivini Track in Huvalu Forest, 2 Fue)	2 (2 Vinivini Track in Huvalu Forest)	Only observed in forested sites

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SHORT NOTE

Pied shags (*Phalacrocorax varius*) devour ducklings and pursuit-dive after adult New Zealand scaup (*Aythya novaeseelandiae*)

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The New Zealand pied shag (kāruhiruhi, *Phalacrocorax varius*), a pursuit-diver of fish in shallow (<10 m) waters (Orta 1992; Harrison *et al*. 2021), is primarily a marine species, but also occurs at freshwater sites, including at Zealandia ecosanctuary/Te Māra a Tāne, Wellington (41°17′S, 174°45′E). There, it has become the dominant breeding shag species beside the lower lake (Bell 2015; Miskelly *et al*. 2023) and here we briefly report on two of its interactions with waterfowl species at Zealandia – predation of ducklings and pursuit-diving after adult New Zealand scaup (pāpango, *Aythya novaeseelandiae*). On several occasions over recent years, pied shags were seen by CG capturing and devouring ducklings on the lower lake. Similar attacks there were reported to CG by other boat skippers. The pied shags attacked by swimming underwater (pursuit-diving) and coming up underneath each duckling, then seizing and devouring it (see Fig. 1).

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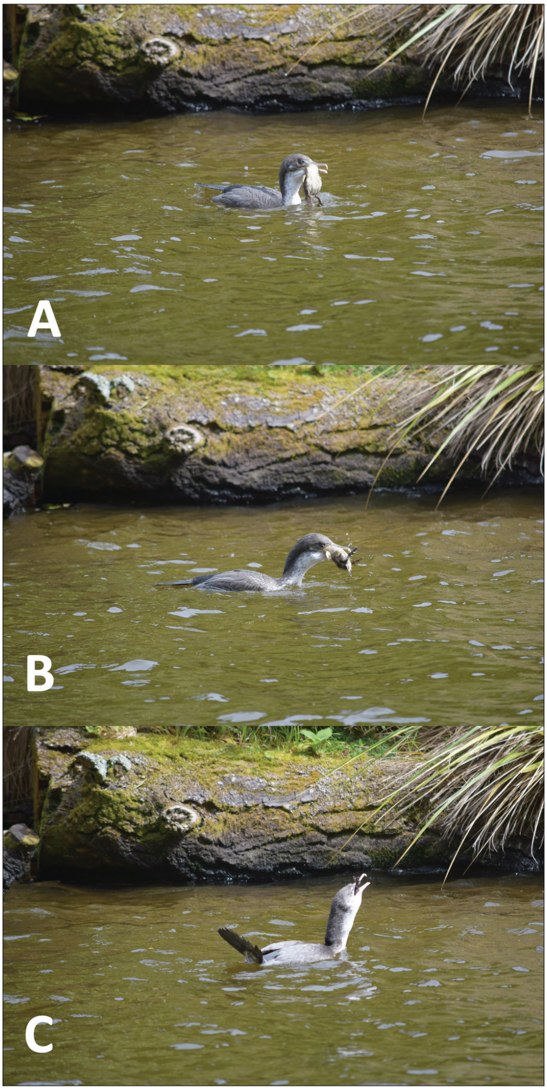

Figure 1. Sequence of photographs (A to C) of a pied shag capturing and devouring a duckling on the lower lake at Zealandia ecosanctuary, Wellington, 1022 h on 16 November 2017. (Photographs: Chris Gee).

During January–May 2023 pied shags were seen by BDB harassing adult New Zealand scaup at Zealandia. On 9 January 2023 at the north end of the lower lake, an adult pied shag swam towards, then pursuit-dived behind an adult female New Zealand scaup on repeated occasions. Each time, the pursuit caused the scaup to take-off and land again on the lake 10–15 m away. This recurring sequence of *shag chase – shag dive – scaup take-off* occurred over five minutes (1320–1325 h), until the New Zealand scaup flew off to settle on the lake *c.* 40 m away, after which the pied shag left it alone. Again, at 0950 h on 28 April 2023, at the north end of the same lake, two pied shags pursued a pair of New Zealand scaup, then one of the pied shags, an adult, pursuit-dived behind the female scaup, both scaup then taking off before settling on the lake edge *c.* 50 m away. Later that day (1348 h) a juvenile pied shag approached, then pursuit-dived, behind a female New Zealand scaup at the south end of the lake, the duck again flying away *c.* 80 m towards the lake edge. Shortly afterwards (1355–1400 h), three pied shags were seen near another pair of New Zealand scaup at the north end of the lake, two of them swimming directly towards the two ducks, one again pursuit-diving behind the female scaup, causing both scaup to again take off and land *c.* 60 m further down the lake.

The predation of ducklings we report was mostly done by semi-mature juvenile pied shags yet to disperse from their Zealandia breeding site. They were able to fly, but possibly not strongly enough to head off to sea to fish for themselves, and it may simply be that they were the individuals around the lake, waiting for the adults to return with food. The duckling species involved in pied shag predation could not be confirmed, but brown teal (pāteke, *Anas chlorotis*), mallard (rakiraki, *Anas platyrhynchos*), New Zealand scaup, and paradise shelduck (pūtangitangi, *Tadorna variegata*) breed at Zealandia (Miskelly *et al*. 2023). It is of interest that pursuit-diving, a widely used behaviour when feeding at sea (Harrison *et al*. 2021), is employed in different contexts at Zealandia: duckling predation and harassment of adult ducks, that might incur injury even if not devoured. Furthermore, our observations on predation by pied shags need to be placed into a wider perspective, as opportunistic predation of ducklings occurs frequently, involving many types of predator. Ducklings run the gauntlet of a wide-range of challenges to survival, including predators and unfavourable weather, their number decreasing as the season advances. In most waterfowl species 40–60% of young that hatch die before they are fully grown (Carboneras 1992). At sites like Zealandia, more focussed study of such interactions between pied shags and other waterbird species would clarify the extent and significance of observations reported here, particularly the impact of pied shags on less common waterbirds, such as brown teal and New Zealand scaup.

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SHORT NOTE

A significant remnant population of whio (blue duck, *Hymenolaimus malacorhynchos)* bridging the gap between Fiordland and West Coast Recovery Sites, South Island, New Zealand

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Whio (blue duck, *Hymenolaimus malacorhynchos*) is a globally Endangered/Nationally Vulnerable, New Zealand endemic species, characteristic of clear fast-flowing upland rivers and streams (Baillie & Glaser 2005; Robertson *et al.* 2021; IUCN Red List 2022). The South Island whio is now mostly confined to high-altitude segments of rivers in the Southern Alps Kā Tiritiri o te Moana and Fiordland (Checklist Committee OSNZ 2022). There have been some recent substantial population increases where persistent riparian mammalian predator control exists such as in central North Island and Te Anau-Milford areas (Checklist Committee OSNZ 2022). The only member of its genus (Robertson & Goldstien 2012), the whio is regarded by Kāi Tahu[1] as a highly valued traditional food source, with strong cultural and historic connections over many generations (P. Tamati-Elliffe *pers. comm.* 2022). The presence of whio is deemed to be an indicator of riverine ecosystem health and the completeness of ecological relationships within that ecosystem (Glaser *et al.* 2010).

The long-term goal of the Department of Conservation Whio Recovery Plan (2009–2019) is to ensure the retention of viable wild whio populations throughout their natural range with the identification of new recovery sites for whio management within the under-represented parts

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1 Kāi Tahu and Ngāi Tahu are names for the iwi (tribe) of Māori people in New Zealand's South Island. The K is an important feature of the Kāi Tahu dialect, but is interchangeable with the use of the 'Ng'.

of their former range (Glaser *et al.* 2010). There are currently eight identified whio recovery sites within the South Island of New Zealand where birds are actively managed (Glaser *et al.* 2010; A. Smart *pers. comm.* 2023). Previously, whio in the Landsborough Valley (43°59′0″S, 169°29′0″E) were included as a recovery population but this ended in 2015 (A. Smart *pers. comm.* 2023). Consequently, there is a significant gap (*c.* 350 km), between the whio recovery sites in Fiordland (45°17′0″S, 167°42′04″E) and the West Coast (42°50′55″S, 171°15′30″E) which might hinder natural dispersal and gene flow between populations.

Whio management does not currently include birds of the Makarora (originally known by Māori as Makarore) region (Glaser *et al.* 2010; S. Sutton *pers. comm.* 2022). Whio in this site form an important population, which is not only a remnant population of South Island whio but also one that may bridge the gap between the Fiordland and West Coast Recovery Sites. Despite the importance of the Makarora whio population, there has been little comprehensive survey effort undertaken for whio in the Makarora catchment since the 1980s (Child 1981; Williams 1989). Consequently, little is known about the current population status, distribution, and potential breeding areas of whio within the Makarora catchment. Furthermore, whio from the Makarora catchment were not included in past phylogeographic studies of the species (Robertson *et al.* 2007; Robertson & Goldstein 2012; Grosser *et al.* 2017), hence the relationship of this population to others in the South Island is unknown.

Here we present the findings of a literature review, observational records, protected species dog-assisted surveys (Hufton 2017; Hufton 2023), and genetic analyses of whio from the Makarora catchment and highlight the population as a significant remnant that contains a distinct haplotype that warrants inclusion in the national management of whio.

In the 1980s, the late Peter Child reported whio as relatively rare on both sides of the Main Divide (Southern Alps/Kā Tiritiri o te Moana), in the Makarora and tributaries, with pairs noted at the head of the Makarora, Siberia Stream, the Blue River, Newland Stream, and Cameron's Creek (Child 1981). During his survey, he recorded 22 adults in approximately 2,500 km^2 of Mt Aspiring National Park, noting at the time, "the population was disappointing and probably declining" (Child 1981). Historical landowner records (NZ Archive 1978) include a whio pair located on the true right, of the Makarora River delta at the head of Lake Wānaka. The habitat here has since changed and is no longer suitable for whio. The Blue Duck Liaison Group (Williams 1989) reported: "one pair recorded on the Young and the Blue Rivers. Previously birds had been seen on the Siberia. Local people commented that blue ducks were always found at the same place on the Blue River. The balance of the Blue River appears to have good blue duck habitat but no birds. This raises questions about dispersal and recruitment of whio in South Island valleys." Further monitoring was disregarded given the apparent lack of birds and the remoteness of those few remaining pairs (Williams 1989).

Since the establishment of Aspiring Biodiversity Trust (2017), specialised protected species dog-assisted surveys have been undertaken for whio within the Makarora catchment (Hufton 2023). Sites (Fig 1; Table 1) include; the upper Makarora (originally known by Ngāi Tahu as Wharemanu/ House of the Birds) (Ngāi Tahu Atlas 2021), Siberia Valley (the Siberia River combined with the Crucible and Gillespie streams drains the Southern Alps Kā Tiritiri o te Moana within Mt Aspiring National Park and joins the Ōtānenui/Wilkin River at Kerin Forks, a tributary of the Makarore/Makarora River), upper Wilkin, Wonderland Stream, Newland Stream, the Tiel Creek, Camerons Creek, Blue River, and the Mueller River (west of the main divide). The Young River was surveyed with the aid of a protected species dog during 2017, a survey commissioned by Forest & Bird (van Klink 2017). Environmental DNA (eDNA) freshwater sampling has also been undertaken for several riparian locations (Hufton 2023). Additionally, observational and incidental whio records (2018–2022 seasons) have been compiled (Table 1) to help develop a better understanding of the current whio population status and distribution within the Makarora catchment, to guide best use of resources to optimise species recovery where birds are still naturally residing. Furthermore, several whio feather samples were retrieved from the field (Siberia, Newland; Aspiring Biodiversity Trust [ABT] surveys 2023) for DNA sequence analysis.

Based on the results of the survey work, ABT observations and recent verified whio records (Fig. 1; Table 1), there are currently at least 25 adult whio (comprising 11 pairs) within the Makarora catchment: three pairs in the upper/mid Wilkin; four pairs in the Siberia/Gillespie Stream; one pair in the Tiel, single males in the Cameron and Newland; up to three adults (1 pair) in the Blue; three adults (1 pair) in the Young (with a probable male bias), and a pair in the Levin. With three birds in catchments immediately west of the main divide (Fig. 1) proximal to the Siberia basin east of the main divide. This is promising as Child (1981) identified only 22 adults and up to two young birds from within the entire Mt Aspiring National Park. The Makarora catchment area alone extends to *c.* 800 km^2.

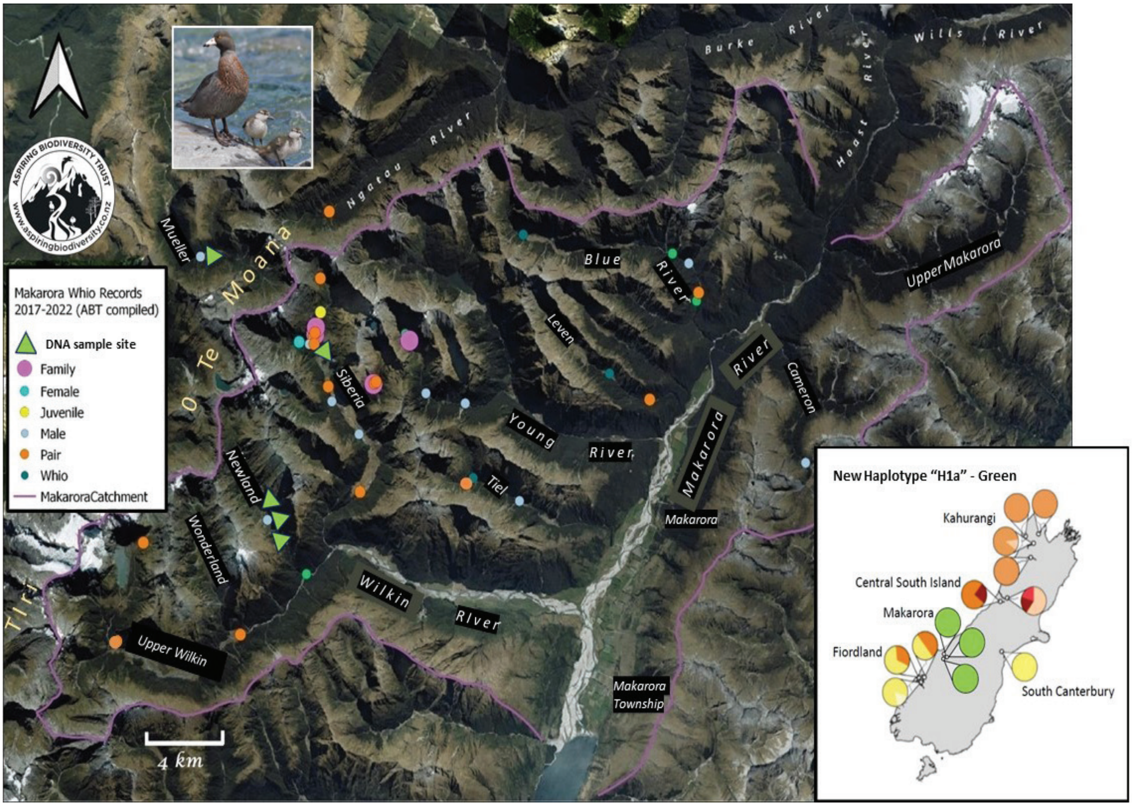

Figure 1. Aspiring Biodiversity Trust (ABT) overview plan of whio (blue duck, *Hymenolaimus malacorhynchos*) records during surveys combined with observations and verified incidental records (individuals, pairs, family 2+ birds) for the Makarora Catchment 2017–2022 (Table 1). Located at the head of Lake Wānaka, in Ōtākou/Otago region of the South Island (44°14′S, 169°14′E). Insert showing distribution of whio mitochondrial control region haplotypes present on South Island of New Zealand (colours represent haplotypes) including the new haplotype H1a (green) detected in four whio samples from the Makarora catchment (Siberia & Newland), and one whio sample from South Westland (Mueller River). This new haplotype is one base pair different from haplotype H1 (yellow colour), which is the most common Fiordland haplotype (Robertson *et al.* 2007; Grosser *et al*. 2017). Modified from Grosser *et al.* (2017). Inset photograph: whio adult with Class 2 ducklings (WRG 2004), Siberia Valley, Makarora (Nick Beckwith; ABT work programme, October 2019).

The Siberia Valley and associated streams are deemed to be high priority for whio recovery in the Makarora catchment as breeding has been confirmed over three consecutive seasons, with up to four ducklings recorded and sensitive moult locations and commuting routes identified (Table 1). Additionally, a whio pair has been recorded for Tiel Creek (a first record for this valley; connecting to the Siberia). Also, whio have been recorded at the head of the Ngatau River (INaturalist 2022) and the Mueller River immediately adjacent to the head of the Siberia basin (Fig. 1). Conjointly, the upper/mid Wilkin Valley is high priority as whio pairs have been confirmed in suitable habitat (Hufton 2023) as similar to that described by Collier *et al.* (1993), Godfrey *et al.* (2003), and Ballie & Glaser (2005), and therefore breeding is possible.

Mitochondrial control region sequences (DNA sequencing following Robertson *et al.* 2007; Grosser *et al.* 2017) from four feather samples collected during ABT surveys of the Makarora catchment (Newland and Siberia) revealed a new haplotype H1a, indicating a previously undetected maternal lineage of whio in the catchment. This new haplotype is one base pair different from haplotype H1 (Fig. 1), which is the most common Fiordland haplotype (Robertson *et al.* 2007; Grosser *et al.* 2017). Previous genetic studies of whio did not include birds from South Westland (Robertson *et al.* 2007; Grosser *et al.* 2017). Genetic analysis of a whio feather sample from the Mueller River (South Westland; ABT survey March 2023) detected the same new haplotype as found in the Makarora whio (Fig 1).

Table 1. Aspiring Biodiversity Trust (ABT) survey chronology, observational (during work programs) and incidental records (received and verified) for whio (blue duck, *Hymenolaimus malacorhynchos*) recorded in the Makarora Wilkin catchment (2017–2022 seasons) South Island, New Zealand. Record via, S = Survey (conservation dog assisted walkover or eDNA water sample), I = Incidental, O = Observational.

Date	Location	Observation	Record via
2017/2018	Young Valley SB	Single male x 2 above swing-bridge	S
	Upper Wilkin	Pair above Top Forks Hut on two occasions	I
	Siberia Basin	Pair and 1 x juvenile, plus possible concealed bird	S
2018/2019	Upper Wilkin	No birds, lots of field signs + feathers, habitat suitable	S
	Upper/Mid Wilkin	Pair, Wonderland/Wilkin Confluence	O
	Blue Valley	Single adult in Feb	I
	Levin Stream	Pair seen in Jan	I
2019/2020	Siberia Valley (upper)	Pair with x 3 ducklings (Oct)	O
	Siberia Valley (lower)	Pair below Siberia airstrip pools	O
	Ngatau Valley	Pair, head basin (adjacent to Siberia basin)	I
	Upper Wilkin	Pair at upper Lucidus/Castalia (1,000 m a.s.l.) in Feb	O
	Blue Valley	No birds, field signs/possible concealed bird	S
	Young Basin SB	Pair with ducklings in Jan	I
2020/2021	Siberia at dusk	Territorial male + female, Siberia head basin	O
	Young Valley NB	Single adult, Young head basin (Nov)	I
	Blue Valley	Single adult in Jan	I
	Siberia /Gellespie	Pair with 1 x duckling Gellespie Stream (Jan)	O
	Tiel Stream	Single adult male, good food availability	S
	Wonderland Valley	No whio or field-signs, habitat/food suitable	S
	Mid/Wilkin Valley	Single adult, Newland Confluence in Jan	I
2021/2022	Upper Siberia	Pair with x 4 ducklings in Oct	O
	Upper Siberia	Pair in Jan	O
	Blue Valley	Single adult in Oct	I
	Upper Makarora	No whio or signs with dog or eDNA, habitat & food good	S
	Siberia NB/Crucible Stream	Adult male and female, moult locations identified	S
	Siberia Valley	Adult male on Siberia after Crucible Stream	I
	Cameron Creek	No whio evidence in eDNA water samples (below hut)	S
	Levin Stream	Pair noted, previously noted in Jan 2019	I
	Mueller River	Pair, 3 Mar 2022 (adjacent to Siberia basin)	I
2022/2023	Siberia Valley	Five seen (pairs flying, guard male/dusk calls)	O
	Siberia Valley	Pair & field signs Gellespie Stream and lower Siberia	S
	Gellespie Stream	Pair seen on two separate occasions in Nov	I
	Blue Valley	Pair above Camp Flat and single male at basin	O
	Cameron	Single male high up in catchment above eDNA points	S
	Newland Valley	Single male in moult, further sign/concealed bird, food good	S
	Gellespie Stream	Single whio at recurring location on the flats (Jan-Mar)	O
	Mueller Valley SW	Single male and concealed bird; feather and faeces	S
	Tiel Valley	Positive eDNA result for north branch near forks, food good	S
	Tiel Valley	Pair, South branch above forks at dusk (Apr)	O
	Wilkin/Siberia/K-Forks	No evidence of whio in eDNA water samples	S

The detection of a new genetic maternal lineage in whio within the Makarora/South Westland area highlights the importance of this area for whio recovery (Fig. 1). Specifically, that whio in this area should be managed as a new recovery site in whio recovery planning, to retain this distinct genetic variation. Whio, however, do not currently feature in the Department of Conservation threatened species protection planning for the Makarora area. Our new understanding of the genetic relationship of the Makarora/South Westland whio to other areas (Fig. 1) should also inform future translocations. Previous studies have recommended that whio should be sourced locally (Robertson *et al.* 2007; Grosser *et al.* 2017), whether that is population to population translocations of wild whio or using Whio Nest Egg (WHIONE) (Whio Recovery Group 2004), where wild eggs are harvested, chicks raised in captivity and subsequently released (Grosser *et al.* 2017). Our findings also provide important insight into whio dispersal between the east and the west of the Main Divide (Southern Alps Kā Tiritiri o te Moana), as shown by haplotype sharing of the Makarora and South Westland whio (Fig. 1). Future studies should aim to resolve the haplotype distribution using additional South Westland feather samples.

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Keywords: whio, *Hymenolaimus malacorhynchos*, makarora, genetics, waterfowl survey, recovery site

BOOK REVIEW

Letters of a Naturalist – The Field Accounts of Richard Henry of Resolution Island.

Edited by Susanne Hill, John Hill, & Victoria Jaenecke.

Putangi Publications, 2022, xii + 458 pp, hardback 300 x 233mm, illustrated colour. ISBN: 978-0-473-64328-7.

Richard Henry (1845–1929) is an underappreciated figure in the early history of natural history and conservation in New Zealand. Born in Ireland and raised in Australia from the age of six, Henry emigrated alone to New Zealand in 1874–5, eventually settling in 1883 at the southern end of Lake Te Anau and making a living through a range of backcountry work. He spent his spare time observing and collecting birds, and began writing articles for local newspapers – although self-educated, he had been fascinated by ecology and animal behaviour from an early age. In 1894, Henry was made curator and caretaker of Resolution Island in Fiordland, and over the next fourteen years made extensive observations and reports on the native fauna and conducted the first conservation translocations in an attempt to save kākāpō (*Strigops habroptilus*) and kiwi (*Apteryx australis* & *A. haastii*) from the rapidly encroaching invasive mustelids. Although his efforts to preserve native species on Resolution were unsuccessful, he pioneered many elements of modern conservation and took a behavioural focus at a time when academia was generally more interested in anatomy and classification.

Letters of a Naturalist is primarily a collection of Henry's writings, presented alongside notes and curated illustrations to help a reader visualise the locations and species mentioned therein. The book itself is colossal, both in terms of size and content, and aims to present Henry's writings in as complete a manner as possible, with enough added contextual and supporting material for a reader to fully absorb and appreciate. To avoid burying the lede, the editors have done an excellent job – this book is a comprehensive and beautiful piece of work with no significant weaknesses, and I wholeheartedly recommend it.

Letters is divided into three main parts and eleven appendices, plus substantial introductory material and end matter. The first part contains Henry's letters, the majority of which are from his time in Dusky Sound. The second part presents extracts from Henry's book *The Habits of the Flightless Birds of New Zealand* (Henry 1903), and the third is split into sections covering miscellaneous natural history observations, speculations, and reminiscences by Henry. The eleven short appendices are a mixture of additional writings from Henry, further details about his work, and new material on topics relevant to Henry and his story. The book is illustrated and contains footnotes throughout that greatly enhance the value of the material and its readability.

Henry's letters represent about half of the total page count of the book. Letters from Dusky Sound (1894–1908) are the largest fraction, but the collection spans well over thirty years from shortly after his arrival in Te Anau to his time at Katikati. While at Dusky Sound, Henry clearly desired not just to report his activities to his employer but to build broader support and interest in conservation, as he wrote over one hundred pieces for newspapers, journals, and societies across the country. As a conservationist Henry was far ahead of his time, being the first to translocate species to predator free islands, the first to train a conservation dog, and the first to understand the irregular breeding of kākāpō – just one example of his keen abilities in observing and recording behaviour.

The letters are not merely dry reports of Henry's work or dispassionate observations – his attitudes and emotions shine through the collection, and a number of letters deal with more personal subjects. Henry's life contained more than its share of tragedy, and in 1893 a gathering gloom fuelled by the loss of a friend, his deteriorating health, and frustration at the slow progress of making the Resolution reserve a reality led to a suicide attempt. Thankfully he survived, received treatment, and was greatly heartened by a supportive telegram from his employer – in his reply letter Henry seems almost cheerful. After three weeks a recovered Henry was ready to get back to work, and in the meantime the bureaucracy preventing his appointment to Resolution had been resolved.

Henry's letters paint a picture of a man deeply troubled by the damage introduced pests were doing to the native avifauna, and the ultimate failure of his efforts on Resolution and the broader apathy around conservation weighed heavily on him. Henry would no doubt be delighted that more than a century later the battles he started are still being fought, and that the techniques he pioneered remain as cornerstones. Although largely unappreciated in his lifetime and for many years after, Henry has begun to receive his due in recent years, with the Department of Conservation marking the 90th anniversary of his death (2019). Hopefully *Letters* will also contribute to wider appreciation of Henry's legacy.

The book contains an almost complete selection of Henry's letters, but the editors have excised some parts containing long digressions or which are repetitive; these omissions are noted in the text. I have not read Henry's original letters so cannot comment on the editors' judgement around what was removed, but their reasons are sound and are presented transparently. Other than those omissions, the editing of Henry's material is light throughout to preserve his unique style, with only punctuation changes and some minor corrections to spelling or for consistency. Overall, the letters do not form a continuous narrative, and the discussions are unfortunately only one-way; but in this the editors had little choice as very few letters written to Henry have survived. Two of the editors of *Letters* previously authored the biography *Richard Henry of Resolution Island* (1987, reprinted 2015), which would serve as a companion volume.

The second part of *Letters* reproduces extracts from Henry's 1903 book *The Habits of the Flightless Birds of New Zealand*, with some minor unpublished revisions and additions made by Henry in 1904. While well-received at the time, few copies of *Flightless Birds* are now in circulation and to my knowledge the complete book has not been digitized. This new work is hence the only readily available source for this material, and the only source for Henry's unpublished 1904 edits. As with part one, some material has been omitted – in this case digressions about other topics of interest to Henry but not about the birds in question.

Flightless Birds was written for a general audience and for a longer format, and as a result the writing in this part is more engaging and has more depth than many of his letters. It is evident that Henry was an excellent natural historian, and had the advantage of living at a time when many species were far more abundant. The editors have added substantial value to this section with their footnotes, which include not only additional information on locations or common knowledge at the time, but also comments from modern scientists on Henry's observations in the context of our current understanding of the bird in question. Weka (*Gallirallus australis*), kākāpō, kākā (*Nestor meridionalis*), Southern brown kiwi (tokoeka, *Apteryx australis*), Fiordland crested penguin (tawaki, *Eudyptes pachyrhynchus*), and paradise shelduck (pūtangitangi, *Tadorna variegata*) are among those given the most attention. Those interested in seeing a sample of Henry's writing can find an extract on kākāpō online via Papers Past (Henry 1904), and will immediately understand the value of the additional material provided by *Letters*; in this case including comments from current kākāpō Science Advisor Andrew Digby, photos of kākāpō, and botanical illustrations of common plants that they eat.

In the third and final main part, the editors present miscellaneous observations, speculations, and reminiscences by Henry. The observations cover a range of topics, from his attempts to poison sparrows (*Passer domesticus*), to former locations of Māori settlement, to extensive notes on the fishes in Dusky Sound. Henry's speculations are likewise varied but interesting – one attributes the decline of the takahē (*Porphyrio hochstetteri*) since European arrival to the introduction of brown rats (*Rattus norvegicus*), although here (and elsewhere in his writings) Henry regards rats to be a greater threat as food competitors to birds than as egg predators. This part concludes with Henry's reminiscences on aboriginal Australians from his time living in Western Victoria as a child and young man, in the traditional territory of the Gunditjmara people. Although many of the terms Henry uses to refer to aborigines are now pejorative, he clearly had great respect for their skills, strove to understand their thoughts and customs, and pushed back on the negative narratives of the time.

Works such as *Letters* that primarily collate and present existing material stand or fall on how much value is added by their organisation, editing, and new contributions, and here the book excels. The six-page introduction gives a thorough overview of Henry, his work, and his time on the islands. The titles and one-sentence summaries before each letter or extract are clear and helpful. There are 1,444 footnotes, which provide additional context or explanation when Henry makes more obscure references or assumes knowledge a modern reader may not possess. The index – invaluable for a work such as this – is detailed and accurate, and a bibliography is also provided. Some other nice touches include a 'portrait gallery' near the start of individuals that are often mentioned in the letters, and a glossary that clarifies some of the alternative names of the species that Henry discusses.

The Illustrations – over 500 in total – are a delightful mixture of modern and period photography, maps, artwork, sketches by Henry, and a few sections of his original letters. They range in size from full-page to small insets within a column, and each has an informative caption including the source collection for historical photographs and documents. The overall production quality is excellent, and the layout and spacing are consistently professional and effective.

In short, there is almost nothing I can criticise about this book. Often labours of love – which *Letters* clearly is – succeed in terms of content but somewhat miss the mark on presentation and overall 'polish' because those aspects of publishing happen last and are outside the spheres of interest or expertise of the authors or editors. *Letters* is the counterexample – the editors were clearly determined that this book would not be released until it could stand as a work of scholarship and alongside any professionally published coffee-table book. How the book came to be is an interesting and poignant tale in itself, but I encourage those curious to read it from the editors themselves in the book's introduction. Commendably, the editors have also committed to donating any proceeds to conservation organisations and recovery programmes.

This is not a book that will appeal to everyone, as it focuses on the details of one man's life and work in one corner of New Zealand during the earliest days of modern conservation. It should also be acknowledged that Henry's letters, while always interesting, are not always riveting reading. However, this book succeeds completely in what it sets out to do, and the editors should be praised for presenting Henry's work so effectively and adding so much value with their illustrations, notes, and organization. I highly recommend this book for anyone with an interest in the history of conservation or of Fiordland, or who simply enjoys large, beautiful books that celebrate New Zealand's wild places. I look forward to dipping back into *Letters* many times in the future.

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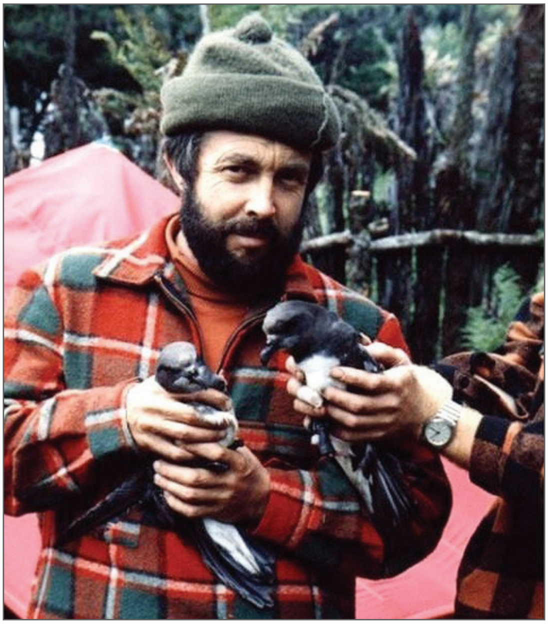
OBITUARY

David Edgar Crockett
25 March 1936 – 24 August 2023



January 1978 - David Crockett with the first 2 taiko caught.[1]

David Crockett was born in 1936. He had one sister, who was killed in the Christchurch earthquake. David and his wife Ruth, met when at training college. As David told the story, he thought he had come first in an exam but discovered that Ruth had beaten him and decided to meet her. With that mischievous grin that he had, he said, "I couldn't beat her in an exam, so I married her!" They were a good team, and while they did not have any children themselves, their lives were dedicated to the education of children.

David was called up in the ballot for compulsory military service at 18, and from the stories he told, it seemed he enjoyed his time in the army. He wasn't one to let the truth get in the way of a good story though, if a little embellishment made it more interesting. He loved to yarn and had a great sense of fun.

I first met David in 1971 when he moved to Whangarei from Whanganui after he had been on an OSNZ Far North field expedition the previous summer and seen what birds the Northland area

[1] The original photographer for this image, to my knowledge, is not known, but it is suggested that it was taken by his wife Ruth. The Chatham Island Taiko Trust, who are in possession of the image, are acknowledged for its use.

had to offer. I think it was the beach patrolling that did it.

On his arrival, he enthusiastically took over the role of Northland and Far North Regional Representative from Sandy Edgar, and roped everyone he could into helping with various OSNZ activities, and particularly beach patrolling. Seabirds were always his passion. Island trips to the Cavalli's and Stephenson's were regular events of those early years. Pouto and Far North Lake Surveys were others. They were fun times. David's orange expedition boxes were a feature of any island trips and these were coincidentally the same colour as Wildlife Service expedition boxes. I remember David being asked by some Wildlife Service personnel once how he got hold of some of their boxes. Allan Wright of the Wildlife Service told me when they went to the Chatham's they had to be careful not to mix up theirs and David's boxes on the wharf.

His work took him all over Northland and he made many contacts during his travels. These were very useful in organising OSNZ activities for help with transport, e.g. along beaches, out to North Cape, etc., for a variety of accommodation options, and of course, for more personnel. He was good at organising these kinds of things.

As science advisor to schools, he encouraged many young people's interest in nature. Junior Naturalist Clubs were fore-runners of the Kiwi Conservation Club now run by the Royal Forest & Bird Protection Society and David ran the local Whangarei Junior Naturalist Club for many years.

As I recall David's story of how he became interested in the tāiko (Chatham Island taiko, *Pterodroma magentae*), was as a 15-year-old schoolboy looking at bird bones in the Canterbury Museum. He researched the bird from then on, for 20 years before his work began on the Chatham's.

David's Chatham Island work began shortly before he moved to Northland, when he partook in a Wanganui Museum Expedition to the Chatham's. His own privately organised Chatham Island Expeditions began in 1972. I was lucky enough to go on the 1974–75 trip to the Chatham's and saw the tāiko on that trip although we did not catch it then.

Although many people suggested it before the first birds were captured in 1978, David was adamant that shooting a tāiko was not an option. In all he made over 100 trips to the Chatham's. Figures I heard at his funeral were 106 and 109. Anyway, it was a lot!

He was well known and respected over there, and I recall a story he told us once, about Manuel Tuanui (the Tuku landowner) ringing him up one morning from the Chatham's, when a Wildlife Service person / scientist arrived at his house seeking permission to go to the Tuku and look for tāiko. Manuel told him, "That's David's bird" and rang David to find out if it was OK with him to let him go.

David had a lifelong involvement with the Ornithological Society. There are articles written by him in *Notornis* going back to 1951 when he was 14. See Appendix. He was a member of the 1964 expedition to the Kermadec Islands, where he studied the wedge-tailed shearwater (*Ardenna pacifica*) on some of the smaller islands. This expedition was cut short, when Raoul Island erupted and people were evacuated.

He was a council member for many years and also served time as Vice President.

David was awarded, in chronological order: the Royal Society of New Zealand's Rutherford Science and Technology Medal in 1996, the Ornithological Society of New Zealand's Sir Robert Falla Memorial Award in 1997, and the Queen's Service Order (QSO) medal in 2000. He put his heart and soul into his Chatham Island tāiko work and he thoroughly deserved these honours.

When Bill Bourne mooted the possibility that *Pterodroma magentae* could be the same as the Chatham Island tāiko, he finished his paper with a paragraph on the conservation situation with the Bermudan cahow (*Pterodroma cahow*), when it was rediscovered after 300 years. It was in "acute danger of extinction". He finished with this sentence, referring to the tāiko; "It may therefore be urgent that the situation of these birds be properly investigated as soon as possible before it is too late to see to their conservation." David Crockett did this and the survival of the tāiko is his legacy.

The last years of his and Ruth's lives were spent at Puriri Court rest home in Kamo, Whangarei. Ruth predeceased him by two years, and David died on 24 August 2023.

PATRICK MILLER
Whangarei

APPENDIX: List of publications by D.E. Crockett.

Tāiko rediscovery

Crockett, D.E. 1979. Rediscovery of the Chatham Island taiko solved century old mystery. *Forest & Bird 13(4)*: *8–13.*

Crockett, D. 1988. A Wild Taiko Chase *Part 4 School Journal Number 1.*

Crockett, D.E. 1994. Rediscovery of the Chatham Island taiko *Pterodroma magentae*. *Notornis (Supplement) 41*: *49–60.*

Imber, M.J.; Crockett, D.E.; Gordon, A.H.; Best, H.A.; Douglas, M.E.; Cotter, R.N. 1994. Finding the burrows of Chatham Island taiko *Pterodroma magentae* by radio telemetry. *Notornis (Supplement) 41*: *69–96.*

Imber, M.J.; Taylor, G.A.; Tennyson, A.J.D.; Aikman, H.A.; Scofield, R.P.; Ballantyne, J.; Crockett, D.E. 2005. Non-breeding behaviour of magenta petrels *Pterodroma magentae* at Chatham Island, New Zealand. *Ibis 147*: *758–763.*

Lawrence, H.A.; Scofield, R.P.; Crockett, D.E.; Millar, C.D.; Lambert, D.M. 2008. Ancient genetic variation in one of the world's rarest seabirds. *Heredity 101*: *543–547.*

Lawrence, H.A.; Taylor, G.A.; Crockett, D.E.; Millar, C.D.; Lambert, D.M. 2008. New genetic approach to detecting individuals of rare and endangered species. *Conservation Biology 22*: *1267–1276.*

Lawrence, H.A.; Millar, C.D.; Imber, M.J.; Crockett, D.E.; Robins, J.H.; Scofield, R.P.; Taylor, G.A.; Lambert, D.M. 2009. Molecular evidence for the identity of the magenta petrel. *Molecular Ecology Resources 9*: *458–461*.

Non-tāiko papers - not a complete list

Crockett, D.E. 1951. Notes from the Christchurch estuary. *Notornis 4(6)*: *137.*

Crockett, D.E.; Kearns, M.P. 1975. Northern little blue penguin mortality in Northland. *Notornis 22(1)*: *69–72.*

Crockett, D.E. 1975. Kermadec Islands Expedition reports: the wedge-tailed shearwater (*Puffinus pacificus pacificus*) in the northern Kermadecs. *Notornis 22(1)*: *1–9.*

Crockett, D.E. 1975. First record of the Antarctic petrel in New Zealand. *Notornis 22(3)*: *249–250.*

Crockett, D.E. 1977. First record of the Christmas Island shearwater in New Zealand. *Notornis 24(4)*: *285–286.*

Crockett, D.E.; Reed, S.M. 1976. Phenomenal Antarctic fulmar wreck. *Notornis 23(3)*: *250–252.*

The Ghost Bird
by Patrick Miller (1975)

In 1867, on a ship south of Tubuai,
A ship's crew shot a seabird,
Subsequently named *magentae*.
They took it back to Italy,
From whence it was described,
By Giglioli and Salvadori,
Men who have long since died.

Then a man named Osbert Salvin,
An ornithologist of some note,
In 1876 of *P. magentae* wrote.
And also a man named Godman
In nineteen hundred and ten,
But then it was forgotten & not heard of again.
Until in 1964 Bill Bourne made the claim,
That *Pterodroma magentae* could be of Taiko fame.

Now the Taiko was a seabird,
Common amongst sub fossil bones,
And known to quite a number,
Of osteological gnomes.
It was formerly found on the Chatham's,
And by the islanders used to be taken,
As a type of muttonbird for their larder,
Of that they weren't mistaken.

The Ghost Bird they had called it,
And of it they had said,
That it very much looked like a bird,
Which did not have a head.
The last time they had taken it was in1903,
But since then only rumours
Of its existence were to be.

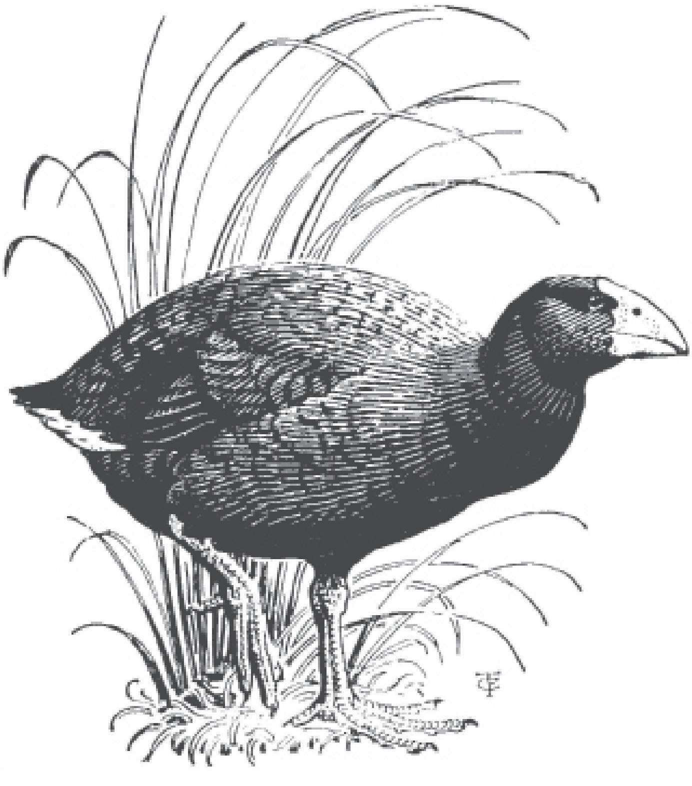
And then along came Davy Crockett,
A dedicated man and true.
He said, "I'll find the Taiko, if it's the last thing that I do."
For 20 years he worked on unrelenting research,
And his dedicated interest was never allowed to lurch.

On his first trip to the Chatham's,
Of the Taiko he found nought,
But that did not deter him,
Again he went and sought.
And this time saw the Ghost Bird
At 10.30 one misty night.
The four of them shivering at the net,
marvelled at the sight.

The Taiko circled overhead and dived right at the net,
But then it banked up steeply and passed it overhead.
So they did not catch the Ghost Bird,
But went away without dismay,
"We shall return," Davy said, "And soon without delay."

The third trip to the Chatham's went off after one slight hitch,
And again they saw the Ghost Bird,
Which again they could not catch.
So the Taiko still roams wild in the bush and out at sea,
But not for long we shall return
And capture one, you'll see.

Note**:** *This poem describes the situation up to the summer of 1974–75. The tāiko was finally captured on 1 January 1978, thus proving to the sceptics its continued existence. David Crockett continued the search after this for its breeding grounds in the bush at the southern end of Chatham Island in the area known as the Tuku, after the Tuku-a-Tamatea River. Conservation work on the tāiko continues to this day.*



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