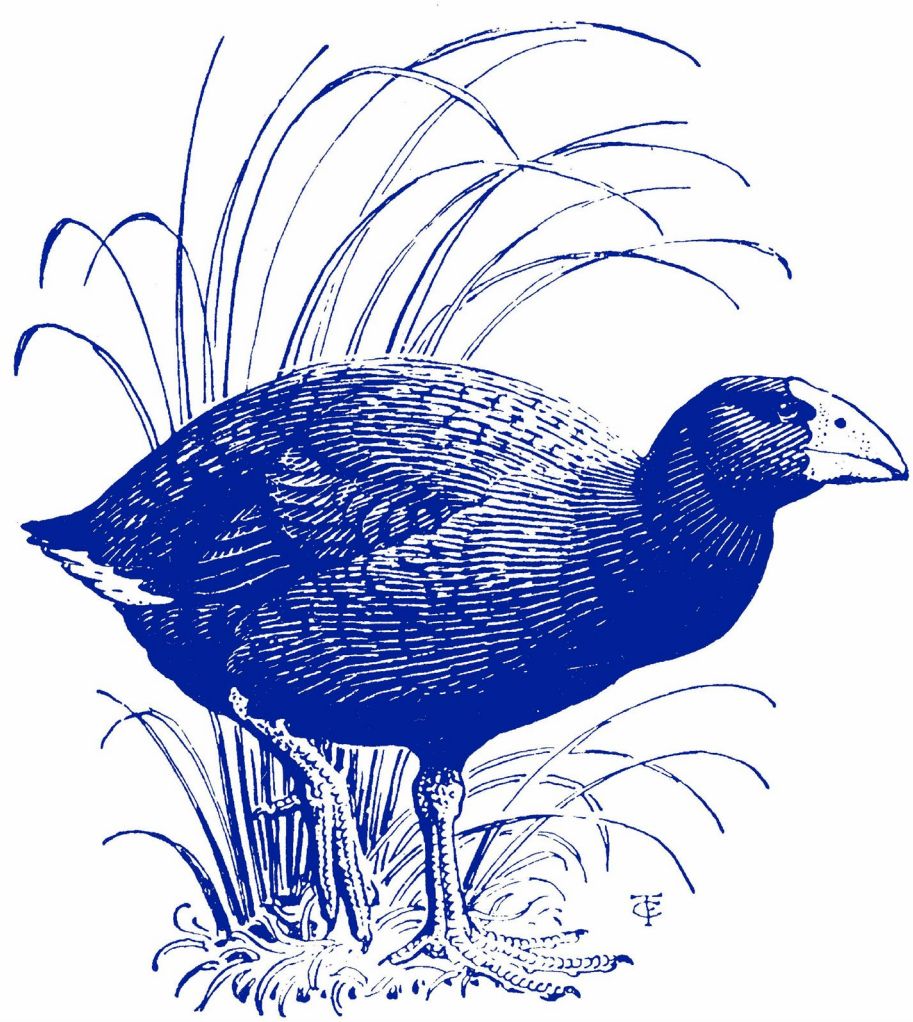
NOTORNIS

Ornithology of the Southern Pacific



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Notornis, Vol. 4, No. 1 (July 1950) (ISSN 1177 7680)
In continuation of Reports and Bulletins (1939-1942) and New Zealand Bird Notes (1942-1950)

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Moult and age determination of New Zealand native passerines

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Abstract: Moult is a vital avian process because it allows the renewal of the worn plumage in an organised way. Moult has a circannual periodicity and tends to differ between the first annual cycle (post-juvenile moult) and subsequent ones (post-breeding moult) of passerines, a fact that can be used to determine the age of individuals. We estimated wing-feather and rectrix moult-extent for 17 New Zealand passerines (excluding introduced species), classified each bird according to eight moult patterns, and computed frequency of wing-feather and rectrix replacement. We combined post-juvenile moult information with that of maturation of feathered and unfeathered characters to provide guidelines for age determination. Our results cover an important gap in the knowledge of the natural history of New Zealand passerines, generate reliable age determination criteria, and thus providing essential information for future conservation actions (including translocations) and to test hypotheses on the ecology and evolution of avian moult in the Australasian region.

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Keywords: annual cycle, moult extent, moult pattern, Passeriformes

INTRODUCTION

The avifauna of New Zealand diversified in the absence of terrestrial predators, a circumstance that drove both the loss of escape instinct and the evolution of flightlessness in several bird groups (Holdaway 1999; Matthews & Triantis 2021). These characteristics made them very vulnerable to hunting and habitat destruction upon arrival of humans, and to predation by the subsequent introduction of other mammals (Duncan & Blackburn 2004). Mainland New Zealand is still home to 20 species of Passeriformes belonging to six of the 12 groups in which the order is divided, including the basal endemic suborder Acanthisitti (Table 1; Winkler *et al.* 2015; Fjeldså *et al.* 2020). Although conservation efforts in the last decades have proven successful for some endemics, several may become extinct in the mid-term as a consequence of the planetary biodiversity crisis (Table 1; Matthews *et al.* 2024). Ongoing conservation challenges will benefit from a better understanding of the biology and population dynamics of New Zealand endemics, which will allow more informed management decisions (Williams *et al.* 2002).

Moult is an important gap in the knowledge of the biology of New Zealand endemic passerines and is currently not described for most species. Moult is a vital trait of avian biology because it allows the necessary renewal of deteriorated plumage. It typically occurs once a year in non-migratory species (all New Zealand passerines except silvereye tauhou *Zosterops lateralis*; Dennison *et al.* 1981), right after the breeding season (between October and January in New Zealand passerines; Higgins *et al.* 2001, 2006; Higgins & Peter 2002), has a circannual periodicity, and tends to differ between the first annual cycle (i.e., the period between hatch and the first post-breeding moult) and subsequent ones; these characteristics are routinely applied to determine bird age (Jenni & Winkler 2020a), which is a crucial parameter for population and ecological studies.

Bird somatic maturation can be assessed using feathered (i.e., plumage) and unfeathered characters. Plumage matures in a discrete way, through moult (Jenni

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Table 1. Data sources and sample sizes for the post-juvenile moult of 17 New Zealand native passerines, and the pre-breeding (pn) moult of New Zealand pipit. We did not gather data from Chatham Islands birds.

Familiy	Species		IUCN category	Source	n
Acanthisittidae	Rifleman Tītipounamu	*Acanthisitta chloris*	Least concern but decreasing	Image libraries Museum	8 5
	Rock wren Pīwauwau	*Xenicus gilviventris*	Endangered	Image libraries	17
Meliphagidae	Tūī	*Prosthemadera novaeseelandiae*	Least concern but decreasing	Museum	14
	Bellbird Korimako	*Anthornis melanura*	Least concern but decreasing	Banding Museum	10 9
Acanthizidae	Grey warbler Riroriro	*Gerygone igata*	Least concern stable	Banding Museum	5 15
Mohouidae	Whitehead Pōpokotea	*Mohoua albicilla*	Least concern stable	Banding Museum Image libraries	5 3 1
Rhipiduridae	New Zealand fantail Pīwakawaka	*Rhipidura fuliginosa*	Least concern but decreasing	Banding Museum Image libraries	8 14 1
Callaeidae	North Is kokako Kōkako	*Callaeas wilsoni*	Least concern and increasing	Museum	4
	North Is saddleback Tīeke	*Philesturnus rufusater*	Near threatened but increasing	Banding Image libraries Museum	2 3 5
	South Is saddleback Tīeke	*Philesturnus carunculatus*	Least concern and increasing	Image libraries Museum	5 1
Notiomystidae	Stitchbird Hihi	*Notiomystis cincta*	Vulnerable	Banding Image libraries Museum	1 9 2
Petroicidae	Tomtit Miromiro	*Petroica macrocephala*	Least concern but decreasing	Banding Image libraries	1 16
	South Is robin Toutouwai	*Petroica australis*	Least concern but decreasing	Banding Museum	1 10
	North Is robin Kakaruai	*Petroica longipes*	Least concern but decreasing	Banding Image libraries	2 1
Hirundinidae	Welcome swallow Warou	*Hirundo neoxena*	Least concern and increasing	Banding Image libraries	6 14
Zosteropidae	Silvereye Tauhou	*Zosterops lateralis*	Least concern stable	Banding	24
Motacillidae	New Zealand pipit Pīhoihoi	*Anthus novaeseelandiae*	Least concern stable	Image libraries Image libraries	31 38
	Pīhoihoi (pn)				

& Winkler 2020b), whereas unfeathered characters (e.g., iris colour and skull pneumatisation) mature in a continuous way, typically over the course of the first 3–6 months of a passerine's life (Yunick 1981; Polakowski *et al.* 2020). In passerines, three features of the maturation process are relevant to age determination. First, the juvenile and the adult aspect differ (i.e., the outer appearance as we perceive it). Second, the definitive adult plumage is acquired either during the post-juvenile moult undergone in the first months of life (which is complete in about 25% species; Delhey *et al.* 2020), or during the first post-breeding moult, with the exception of some manakins that do not acquire the adult coloration during the first post-breeding moult (Doucet *et al.* 2007; Scholer *et al.* 2021) and those Holarctic long-distance migratory species that undergo a complete moult away from the breeding grounds (Jenni & Winkler 2020a; Pyle 2022; Norevik *et al.* 2020). Given that the post-breeding moult of passerines is complete, a mixture of juvenile and non-juvenile feathers in a bird indicates that it has not undergone the post-breeding moult yet. Third, some components of moult are predictable (e.g., sequence of primaries in the complete moult, post-juvenile moult-extent versus post-breeding moult-extent within species; Jenni & Winkler 2020a; Pyle 2022). Therefore, it is only feasible to determine whether a passerine bird is either in its first annual-cycle (which includes the juvenile stage) or in a subsequent one. First-cycle birds (see Glossary Box for technical terminology) of species that undergo a complete post-juvenile moult may be identified until approaching the end of this moult (while the last recognizable juvenile feathers have not been shed yet) or until their unfeathered characters near full maturation, although skull pneumatisation usually ends after the end of the post-juvenile moult. In species undergoing a partial post-juvenile

moult, age determination beyond the full maturation of unfeathered characters can be made using moult limits, the contrasting boundaries that appear between the old juvenile feathers and the post-juvenile ones.

We estimated wing-feather and rectrix moult-extent for all mainland native passerines except fernbird mātātā *Poodytes punctatus*, brown creeper pīpipi *Mohoua novaeseelandiae*, and yellowhead mohua *Mohoua ochrocephala*. Along with these estimates, we classified the final moult-phenotype (i.e., identity of feathers replaced after finishing moult) of each bird according to nine patterns (Guallar & Jovani 2020a). We also computed frequency of wing-feather and rectrix-moult to inform where to find moult limits within the flight feathers (Jenni & Winkler 2020a). We combined post-juvenile moult information with that of maturation of feathered and unfeathered characters to provide guidelines for age determination.

GLOSSARY

First-cycle bird. Bird in its first annual cycle, from hatching until the first post-breeding moult, approximately one year later. This term includes birds in juvenile and post-juvenile plumage (i.e., after the post-juvenile moult).

Moult components. Measurable aspects of moult. They can be grouped in process components (feather growth rate, sequence, intensity, and timing) and output components (symmetry, duration, extent, final phenotype, and plumage quality).

Moult episode. Each separate moult event in the annual cycle of birds. Some species can interrupt moult and resume it later (e.g., Hirundinidae). Three main episodes are recognised: post-breeding, which produces the post-breeding plumage; post-juvenile, which produces the post-juvenile plumage; and pre-breeding, which produces the breeding plumage.

Moult extent. Amount of plumage replaced during a moult episode. Here, it has been quantified as number of feathers.

Moult limit. A boundary between moulted and retained feathers after a moult episode is finished. Usually refers to boundaries between feathers of the same tract but can be used for indicating boundaries between feather tracts.

Moult patterns. Classes of moult phenotypes that share some similarity rules (specified in Fig 2).

Moult phenotype. The identity of feathers replaced by a bird after finishing a moult episode.

Secondary coverts. All upper wing coverts except the primary coverts.

MATERIALS AND METHODS

Moult extent and pattern

We gathered moult data of New Zealand passerines (excluding the Chatham Islands) from three sources: banding, specimens in the collection of Te Papa and Auckland museums, and online image libraries, excluding birds from the Chatham Islands (Table 1; Guallar *et al.* 2025). Moult scoring was essentially the same, although in photos, rectrices tended not to be visible; and spread wings were easier to score than folded ones in specimens (Carrillo-Ortiz *et al.* 2021). We assigned the (finished) moult of birds to each of three moult episodes defined from stage of the annual cycle: (1) post-juvenile, the moult of the juvenile plumage undergone during the first months of life; (2) post-breeding, the moult undergone after breeding by birds hatched in previous years; and (3) pre-breeding, a second annual moult undergone by some species usually at the end of the wintering period (Salewski *et al.* 2004; Jenni & Winkler 2020b). We scored each feather on one wing (Fig. 1) and one half of the tail from 291 birds that had finished moult or were in the last stages of the post-juvenile and pre-breeding moults (i.e., no more wing or tail feathers were likely to be moulted): 1 when moulted (new feather) and 0 when retained (old feather). We scored the proportion of replaced marginal coverts as a decimal between 0 and 1 (Guallar *et al.* 2021). We also scored the percentage of moulted body feathers.

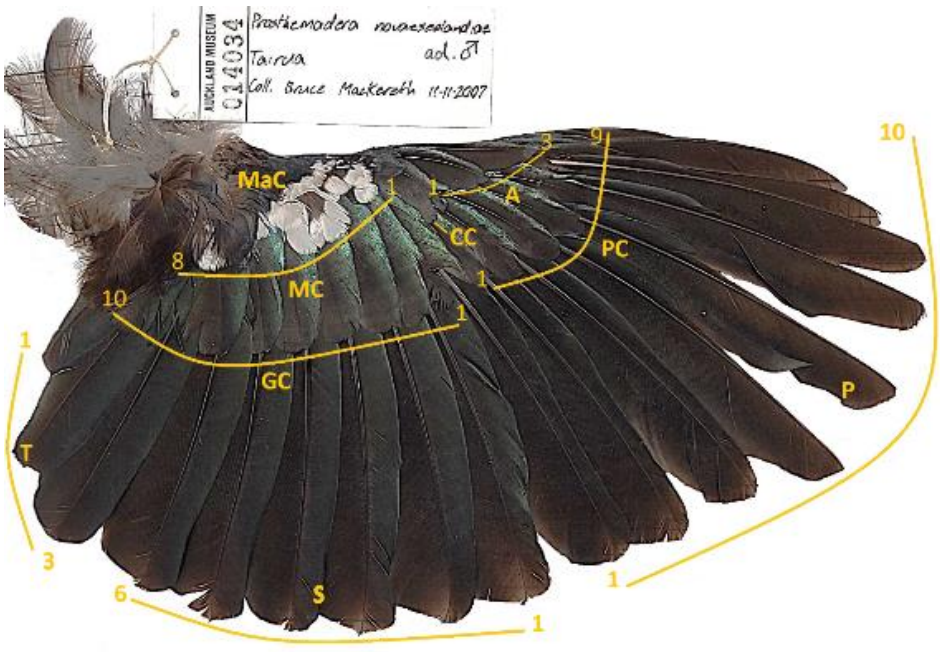
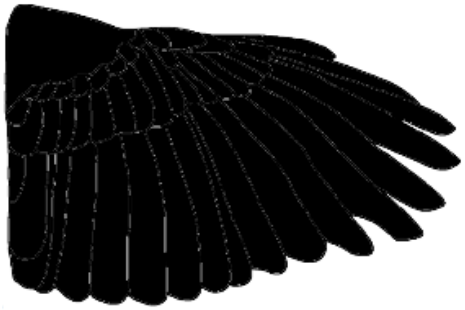
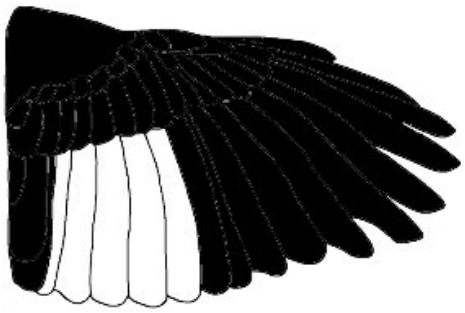
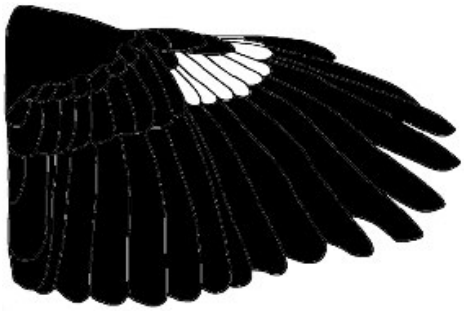
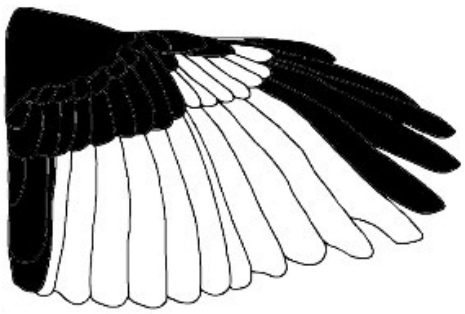


Figure 1. Feather tracts and numbering on the right wing of a tui. GC10 and four inner median coverts not visible. We adhered to the numbering system proposed by Jenni & Winkler (2020b) save for the tertials, whose moult timing and sequence clearly differs from that of the secondaries. P: primaries, S: secondaries, T: tertials, PC: primary coverts, GC: greater coverts, A: alula feathers, CC: carpal covert, MC: median coverts, MaC: marginal coverts. Photo by the authors.

Table 2. Observed moult patterns in New Zealand native passerines. Except the complete pattern, the remaining patterns show variation in the feathers moulted (always within the rules of similarity). The first three patterns include all rectrices, and the eccentric usually too. We only show a typical example per moult pattern. Replaced (new) feathers shown in black, retained (old) feathers in white.

Moult pattern	Definition
	Complete: Full feather moult. Primaries are moulted by accompanying primary coverts when underway.
	Abridged1: An otherwise complete moult with a variable number of retained secondaries.
	Abridged2: An otherwise complete moult with a variable number of retained primary coverts.
	Eccentric: Retention of a variable number of inner primaries and outer secondaries, and most to all primary coverts.

Individual moult extent was calculated as the mean number of wing feathers and rectrices moulted. Therefore, the score for a completely moulted wing (all feathers replaced) was 51 (including species with nine visible primaries; Hall 2005) and the complete rectrix-moult extent was 6 (4 for Acanthisittidae species, which only have eight rectrices). Mean and 95% confidence intervals of wing-feather and rectrix moult extent for each species were estimated applying Bayesian bootstrapping as implemented in library *bayesboot* (Bååth 2016; R Core Team 2025), an adequate method for small datasets and/or variables which do not reasonably fit a known distribution.

We classified each bird's final moult phenotype into one of nine moult patterns defined by rules of similarity (Table 2; Guallar & Jovani 2020a). Frequency of wing-feather and rectrix replacement was computed as the mean score for each feather across birds for every species.

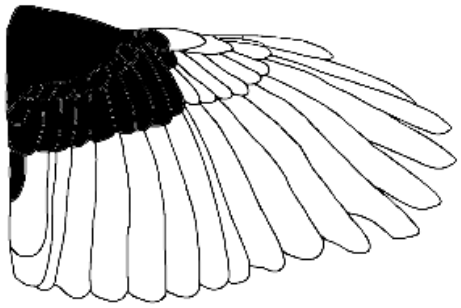
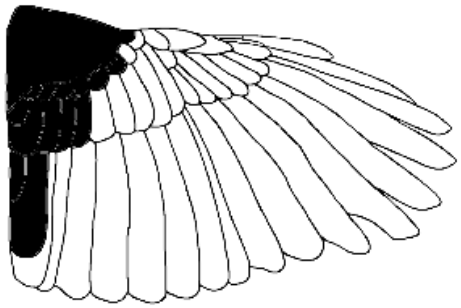
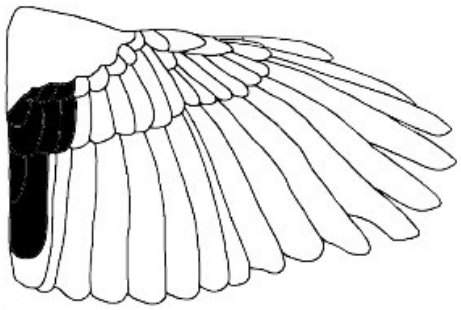
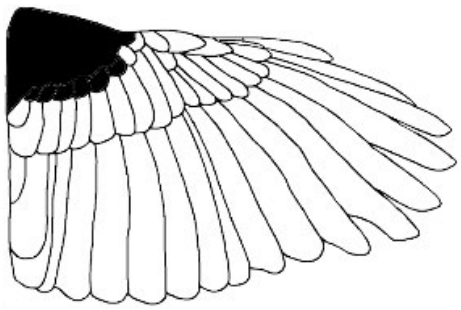
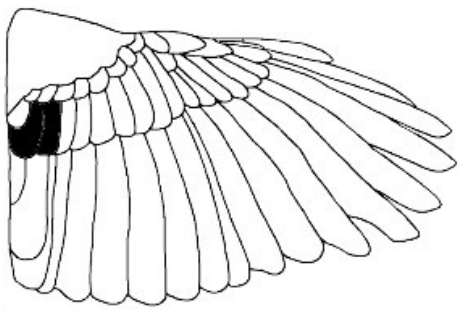
Age determination

We used the following plumage and moult characters to determine the age of birds: juvenile plumage, moult sequence in actively moulting birds, moult limits in birds that had finished moult, and dynamics of feather deterioration (largely fade and wear) throughout the annual cycle for all birds (Fig. 2).

Passerine juvenile feathers differ from adult ones largely by three features: shape, which tends to be shorter and narrower, with more pointed tips; colour, which tends to be duller; and structure, which tends to be looser, of a worse quality, and therefore more prone to fade and wear.

Partial and complete moults can be identified by the sequence of activation of wing-feather tracts. Thus, the complete moult typically starts at the inner primaries with their corresponding primary coverts. Primary moult proceeds outward and usually finishes when the last 1–3

Table 2. *continued*

Moult pattern	Definition
	General: Replacement of secondary coverts. Tertials moulted only if all secondary coverts are moulted. Prioritisation from leading to trailing edge of wing.
	Proximal: Prioritisation of wing feathers closer to the body over those of the outer wing. Tertials replaced with retention of outer secondary coverts.
	Inverted: Prioritisation of feathers closer to the body from trailing to leading wing edge, ie., tertials, inner secondaries, and inner greater coverts over median and marginal coverts (the latter tending to 0%). Body moult tends to be incomplete.
	Limited: Moult of marginal coverts. This usually includes median coverts.
	Reduced: 2-4 wing feathers (secondaries, tertials, median, or greater coverts) and rectrices, without a clear priority. Incomplete body moult.

innermost secondaries are still growing (Zeidler 1966; Guallar & Quesada 2023). Partial moults (except the abridged2 pattern (Table 2), which can only be identified at late stages of the moult progress) will show neither of these, rather an intense body and wing-covert moult without primary moult. Eccentric moults can be confused with complete moults; however, moulting primaries are not accompanied by primary coverts and the sequence of activation of other wing-feather tracts will also differ (Fig. 3; Guallar 2024).

Detectability of moult limits vary within and among species, as well as with timing within the annual cycle.

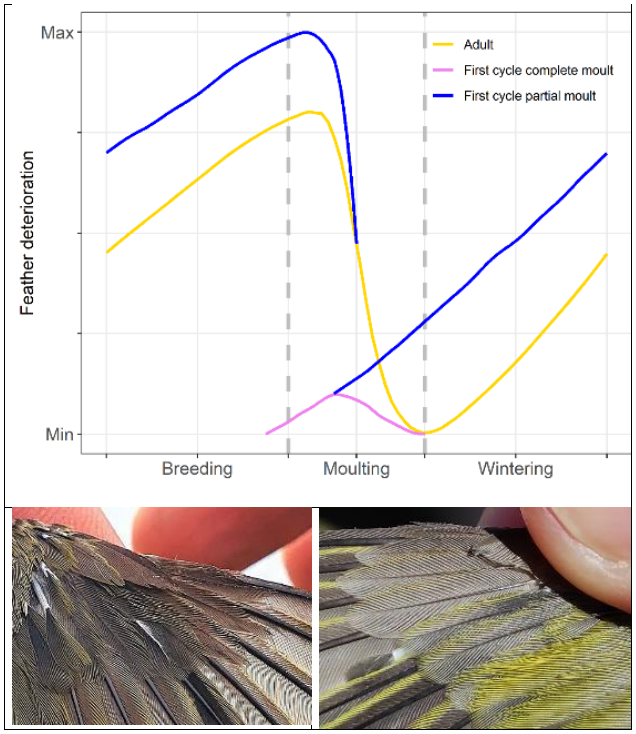


Figure 2. Theoretical dynamics of plumage deterioration by age throughout the annual cycle. Below: differences in deterioration between one adult (left; 20 Mar 2022) and one juvenile silvereye (right; 3 Feb 2025). The outer four primary coverts are old in both birds, but notice that they are faded and ragged in the adult and still fresh in the juvenile. Photos by the authors.

The feather tracts showing moult limits and conspicuousness of the latter tend to be species-specific (e.g., very subtle in North Island kokako *Callaeas wilsoni* and obvious in grey warbler riroriro *Gerygone igata*). We looked for contrasts within and among wing-feather tracts (also among rectrices) using differences in shape, colour, and wear between the retained and the moulted feathers. Considering that contrasts between juvenile and post-juvenile feathers are often subtle, we calibrated our search using museum specimens and online images of the juvenile plumage.

Feather deterioration is expected to peak at the end of the annual moult cycle (Rogers 1990; Guallar *et al.* 2009; Fig. 2) and is aggravated in the retained juvenile feathers of first-cycle birds for two reasons: the juvenile plumage grew several weeks before the adults started their post-breeding moult (the juvenile plumage is worn longer) and the quality of juvenile feathers is generally inferior (Pap *et al.* 2007). This was the main criterion used for determining age in species with a complete post-juvenile moult: moulting adults and first-cycle birds will be readily aged because the retained adult feathers will be one year old and hence worn, and the juvenile feathers will still be fresh (Fig. 2).

We used all potential unfeathered characters to determine the age of banded and photographed birds, including presence of a soft bill gape, palate colour, wattle development, iris colour, and skull pneumatisation. Since we neither scored nor recorded these variables, we will only comment on their qualitative use as complementary ageing criteria.

RESULTS

Moult extent and pattern

The post-breeding moult was complete, although it could be suspended in welcome swallows warou *Hirundo neoxena* (Guallar *et al.* 2025). We found that most New Zealand pipits pīhoihoi *Anthus novaeseelandiae* underwent a pre-breeding moult, which was characterised by partial retention of body feathers and by the presence of wing-feather moult-patterns not found in the post-juvenile moult of any other New Zealand passerine species. In subantarctic islands (e.g., Campbell, Enderby), the pre-breeding moult of Auckland Island pipits *A.n. aucklandica* was frequently lacking or restricted to a few body feathers (Table 3).

All species in our sample replaced body and marginal coverts during the post-juvenile moult. Mean post-juvenile wing-feather moult-extent ranged from 9.5 in South Island robin kakaruai *Petroica australis* to 50.9 in welcome swallows and silvereye (median across species= 18.7). Nine species replaced one to all rectrices during the post-juvenile moult. Individuals in 15 species did not replace rectrices, whereas individuals from seven species replaced them all (Guallar *et al.* 2025; Table 3).

We found nine patterns associated with the post-juvenile moult (Table 2). The abridged patterns were found at low frequencies in the welcome swallow and silvereye, two species that otherwise mostly undergo complete post-juvenile moults. We also found the abridged2 pattern in the post-breeding moult of two rifleman tītipounamu *Acanthisitta chloris* and one tūī *Prosthemadera noveaeseelandiae* (Guallar *et al.* 2025). The general pattern was present in all species except welcome swallow and silvereye, which mostly undergo a complete post-juvenile moult. The inverted and reduced patterns were only present (and were predominant) in the pre-breeding moult of New Zealand

Figure 3. Differences between the complete- and the eccentric-moult sequences in two first-cycle birds. Left (complete): primary P9 finishing growth, secondaries S5 and S6 still growing (silvereye, Nelson 14 Mar 2025). Right (eccentric): primaries P8 through P10 growing in, all secondaries old, and tertials T1 and T3 growing in (bellbird, Tiritiri 20 Feb 2025). Photos by the authors.

Table 3. Bootstrapped estimates (mean and 95% bootstrapped confidence intervals) of post- juvenile and pre-breeding moult-extents on the wing and tail and presence of species showing every moult pattern (nine columns on the right) in New Zealand native passerines.

	n	wing	tail	complete	abridged1	abridged2	eccentric	general	proximal	inverted	limited	reduced
Post-juvenile		**mean[95% CI]**	**mean[95% CI]**									
Rifleman	13	24.7 [20.5-28.6]	2.5 [1.4-3.4]	0	0	0	7	3	3	0	0	0
Rock wren	17	19.6 [18.3-20.9]	0.1 [0-0.3]	0	0	0	0	16	1	0	0	0
Tui	14	23.5 [20.0-27.2]	0.6 [0.1-1.5]	0	0	0	2	12	0	0	0	0
Bellbird	19	23.6 [19.7-27.0]	1.4 [0.5-2.4]	0	0	0	11	8	0	0	0	0
Grey warbler	20	17.0 [15.1-18.9]	1.0 [0.1-1.9]	0	0	0	0	12	7	0	0	0
Whitehead	9	19.8 [17.8-21.5]	0	0	0	0	0	9	0	0	0	0
New Zealand fantail	23	19.1 [17.7-20.5]	4.79 [3.9-5.8]	0	0	0	0	10	11	0	0	0
NI kokako	4	9.3 [1.3-17.4]	0	0	0	0	0	2	0	0	2	0
SI saddleback	6	11.8 [8.5-14.0]	0	0	0	0	0	5	1	0	0	0
NI saddleback	10	16.1 [11.7-20.0]	0	0	0	0	0	8	0	0	2	0
Stitchbird	12	18.8 [17.0-20.6]	0	0	0	0	0	12	0	0	0	0
Tomtit	17	13.5 [11.8-15.0]	0	0	0	0	0	13	2	0	2	0
NI robin	3	13.6 [11.1-15.7]	0	0	0	0	0	2	1	0	0	0
SI robin	11	9.5 [7.3-11.6]	0	0	0	0	0	5	0	0	6	0
Welcome swallow	20	50.9 [50.8 - 51]	6	18	2	0	0	0	0	0	0	0
Silvereye	24	50.9 [50.8 - 51]	6	23	0	1	0	0	0	0	0	0
New Zealand pipit	31	11.6 [9.5-13.7]	0.4 [0.2-0.6]	0	0	0	0	4	24	0	3	1
Presence (%)				16.4	0.8	0.4	8	48.4	20	0	5.6	0.4
Pre-breeding												
New Zealand pipit	38	3.6 [2.5-4.6]	0.1 [0-0.2]	0	0	0	0	0	2	10	3	23

pipit (Table 3). Intraspecific variation in moult pattern was much lower, with only three species showing up to three patterns (median= 2; Table 3).

Because of the low sample sizes, the absolute frequencies at which moult patterns are present in our dataset should be taken with caution.

Age determination

Ageing guidelines for each species are provided below (summarised in Table 4). Greater coverts (15 species) and tertials (14 species) were the feather tracts that exhibited moult limits most frequently. They were followed by the alula feathers (eight species) median coverts (seven species), rectrices (five species) marginal covert (three species) (Table 3).

Rifleman tītipounamu: mottled juvenile body plumage was age diagnostic until the end of the post-juvenile moult (Fig. 4). Afterwards, moult limits were found between the blacker outer moulted primaries and the browner inner retained ones (seven of 13 cases, which underwent eccentric moults) or within the greater coverts and the tertials (six birds that did not moult primaries). Juvenile primary coverts were browner than the adult black ones, contrasting with adjacent post-juvenile greater coverts, alula feathers and primaries.

Rock wren pīwauwau *Xenicus gilviventris*: the juvenile plumage did not contrast starkly with the post-juvenile one (Fig. 4). Moult limits were typically found between the duller brown moulted outer greater coverts and the retained greener inner ones. Also, between brown retained primary coverts and the moulted black alula feathers.

Tūī: the dull juvenile body plumage, with reduced throat tufts and lacking specialised mantle feathers, was age diagnostic until the end of the post-juvenile moult (Fig. 5). Afterwards, moult limits were typically found between the dull retained tertials and alula feathers contrasting starkly with the iridescent post-juvenile ones. The notch on primary P8 was still lacking in most tūī after the post-juvenile moult (because they retained the juvenile primaries); however, two of 14 birds underwent an eccentric post-juvenile moult that included P8, which acquired the notched shape.

Bellbird korimako *Anthornis melanura*: the juvenile plumage did not obviously contrast with the post-juvenile one, although tertials had buffy margins and the face lacked the purple iridescence. The narrower (or absent) and paler margins on the primary coverts were useful to determine the age after the end of the post-juvenile moult. Moult limits were typically found within primaries, tertials, alula feathers, greater coverts, and rectrices. The notch on the outer primaries was lacking in seven of 18 cases individuals after the post-juvenile moult; however, 11 of 18 individuals had undergone an eccentric post-juvenile moult and their outer primaries had the notched shape.

Grey warbler riroriro: the juvenile plumage was similar to the post-juvenile one. Moult limits were typically found within tertials, greater coverts, and rectrices (Fig. 6). Moulted wing feathers had darker vanes with wider and greener margins. The iris of first-cycle birds was still brownish in March.

Whitehead pōpokatea *Mohoua albicilla*: the juvenile plumage was extremely similar to the adult one, only distinguished by less white on the crown and nape. Moult limits were very hard to discern. Moult sequence and the freshness of retained plumage were the main detection aid of the post-juvenile moult (Figs 2 & 6). Birds that were undergoing a complete moult and did not show noticeable

Table 4. Summary of guidelines for ageing 17 New Zealand passerine species. The column moult limits indicates which feather tracts are more likely to have them. Tracts abridged following Fig 1 (R: rectrices).

species	moult limits	moult patterns	other ageing tips
Rifleman	P, R, A GC, T	eccentric general, proximal	
Rock wren	GC, A	general, proximal	
Tui	P, R GC, T, A	eccentric general	some first-cycle birds have notched p
Bellbird	P, R GC, T, A	eccentric general	some first-cycle birds have notched p
Grey warbler	GC, T, R	general, proximal	iris colour useful until March or later
Whitehead	GC, T	general	
New Zealand fantail	GC, T, A	general, proximal	do not rely solely on colour of gc tips
NI kokako	GC, T MC, MaC	general limited	
SI saddleback	GC	general, proximal	delayed plumage maturation
NI saddleback	GC, T	general limited	
Stitchbird	GC, T, A	general	bill colour useful until March or later
Tomtit	GC, MC MC	general, proximal limited	bill colour useful until March or later
NI robin	GC, T, MC	general, proximal	bill and palate colour useful until March or later
SI robin	GC MC	general limited	bill and palate colour useful until March or later
Welcome swallow	no S	complete abridged1	
Silvereye	no PC	complete abridged2	
New Zealand pipit	GC, T, MC, R MC, MaC	general, proximal limited, reduced	most individuals have moult limits after the pre-breeding moult. Ageing based on shape and wear of PC is recommended

differences in degree of deterioration among remiges and greater coverts were likely hatched in the penultimate breeding season.

New Zealand fantail pīwakawaka *Rhipidura fuliginosa*: the dusky juvenile plumage strongly contrasted with the post-juvenile one. The small spots on the tips of tertials and greater coverts changed from the juvenile tawny to the adult whitish (Fig. 6). Moult limits were typically found within the tertials and greater coverts (carpal covert replaced in six of 23 cases), although five of 19 individuals had moulted all the greater coverts.

North Island kokako kōkako: the juvenile plumage was loose textured but very similar to the adult one both in colour and texture. Moult limits may be found within the secondary coverts (Fig. 7). Some kokako might have a post-juvenile moult restricted to the body. No first-cycle birds had developed adult-type wattles by March.

North Island saddleback tīeke *Philesturnus rufusater*: the juvenile plumage was extremely similar to the adult one. Moult limits were found within tertials and greater coverts, with the post-juvenile feathers being larger and having deeper red and black tones. No first-cycle birds had developed adult-type wattles by March.

South Island saddleback tīeke *Philesturnus carunculatus*: showed delayed plumage maturation. The overall brown juvenile colouration was retained after the post-juvenile moult, contrasting strikingly with the adult one. Moult limits were found among the slightly larger and darker inner greater coverts and the juvenile outer ones (Fig. 7).

Stitchbird hihi *Notiomystis cincta*: the juvenile plumage was similar to the adult-female plumage. Bill melanisation of juveniles was incomplete at least until March. Moult limits were found within greater coverts (54% birds), tertials (38% birds), and alula feathers (23% birds). We did not find moult limits within the rectrices (*contra* Smith *et al.* 2015).

Tomtit miromiro *Petroica macrocephala*: the juvenile plumage was paler, with smudged underparts and the head showing thin pale streaks resembling those of the next two robin species. Bill melanisation of juveniles was incomplete at least until March. Moult limits were subtle, typically found within greater coverts and occasionally (three of 17 birds) within median coverts (Fig. 9). Plumage of Petroicidae species wears very little.

North Island robin toutouwai *Petroica longipes*: the juvenile plumage was similar to the post-juvenile one, although the white belly patch was small and ill-defined. Bill and palate melanisation of juveniles was incomplete at least until March. Moult limits were typically found within the greater coverts, less often within the median coverts, and occasionally within tertials (very low sample size). Moult limits were revealed as a noticeable step between the inner moulted greater coverts (which were larger, darker, and greyer) and the retained juvenile ones (Fig. 9).

South Island robin kakaruai: like North Island robin although moult limits were typically found within the median coverts (six of 11 birds) and the greater coverts (four of 11 birds; Fig. 9).

Welcome swallow warou (Fig. 10): juveniles had less forked tails (due to shorter outer rectrices) and a paler face and throat. Since the head is moulted in the late stages of the moult progress, face colouration was useful to age welcome swallows until late in the wintering season.

Silvereye tauhou: the juvenile plumage was slightly paler than the adult one. Silvereyes could be easily aged using degree of feather deterioration (before and during moult), with juvenile birds showing fresh juvenile feathers and adults showing faded and worn ones (Fig. 10).

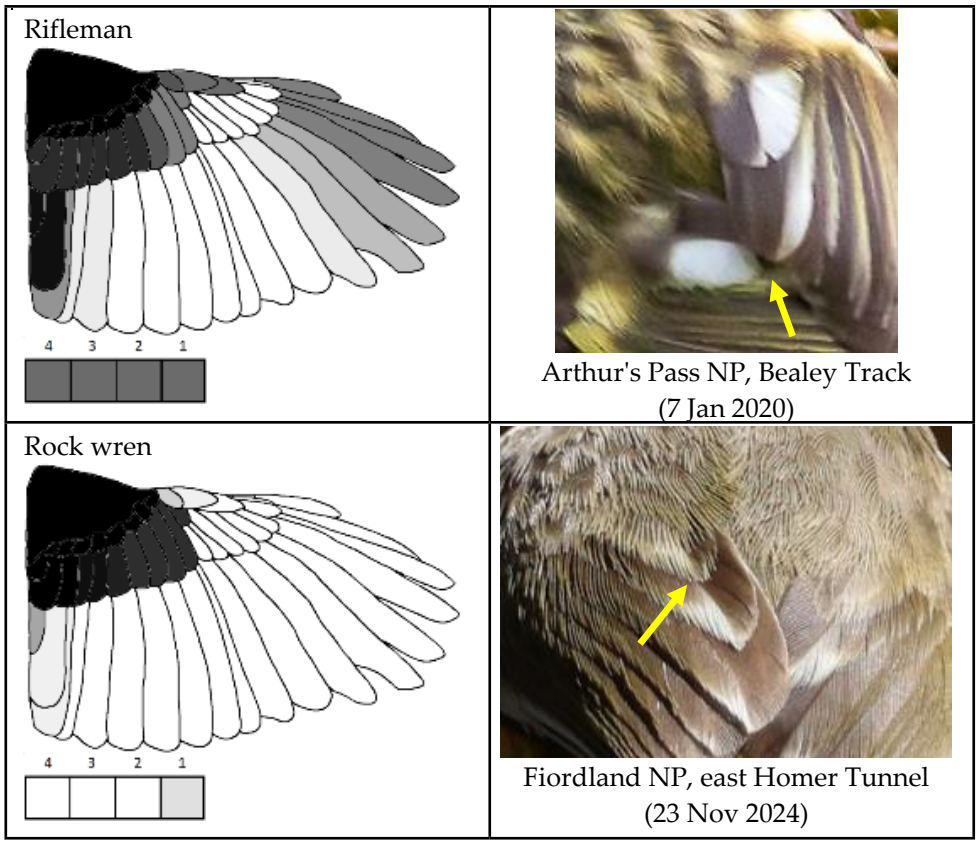


Figure 4. Feather replacement frequency in the post-juvenile moult of New Zealand wrens. Left column: Frequency of wing-feather replacement (top diagram) and of rectrix replacement (bottom squares). Grey shades depict observed percentage of replacement (white = 0%, black = 100%). Right column: Examples of moult limits (indicated by yellow arrows) with localities and dates. Photos used by license agreement from the Macaulay Library.

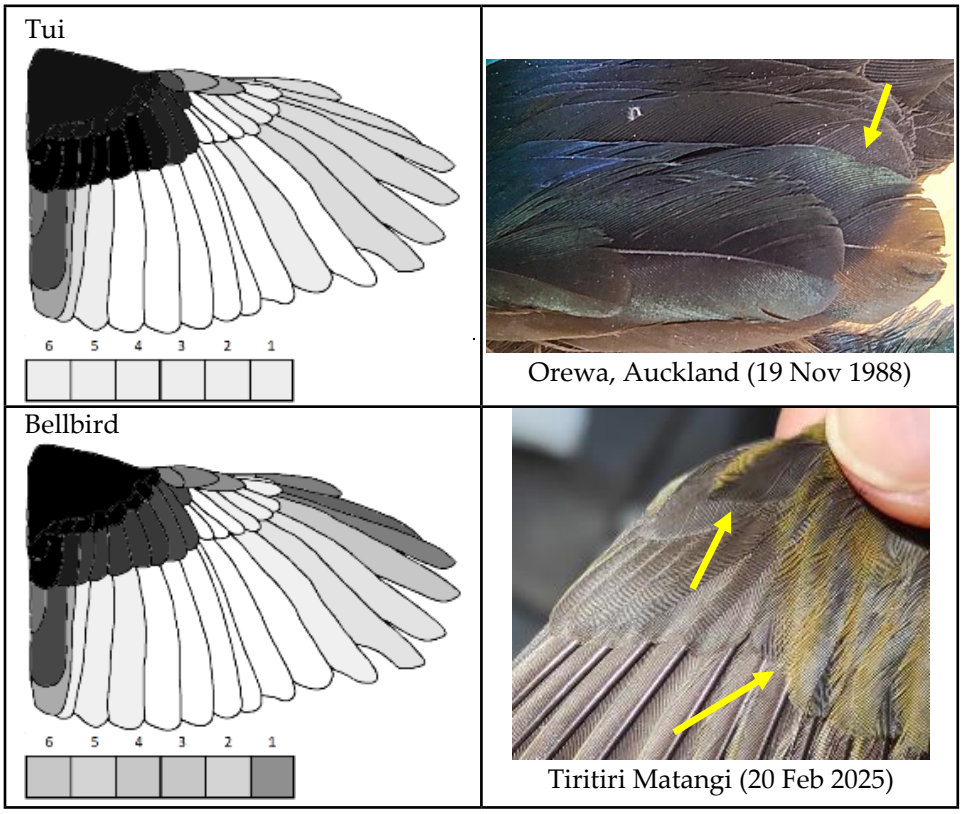


Figure 5. Feather replacement frequency in the post-juvenile moult of New Zealand honeyeaters. Left column: Frequency of wing-feather replacement (top diagram) and of rectrix replacement (bottom squares). Grey shades depict observed percentage of replacement (white = 0%, black = 100%). Right column: Examples of moult limits (indicated by yellow arrows) with localities and dates. Photos by authors.

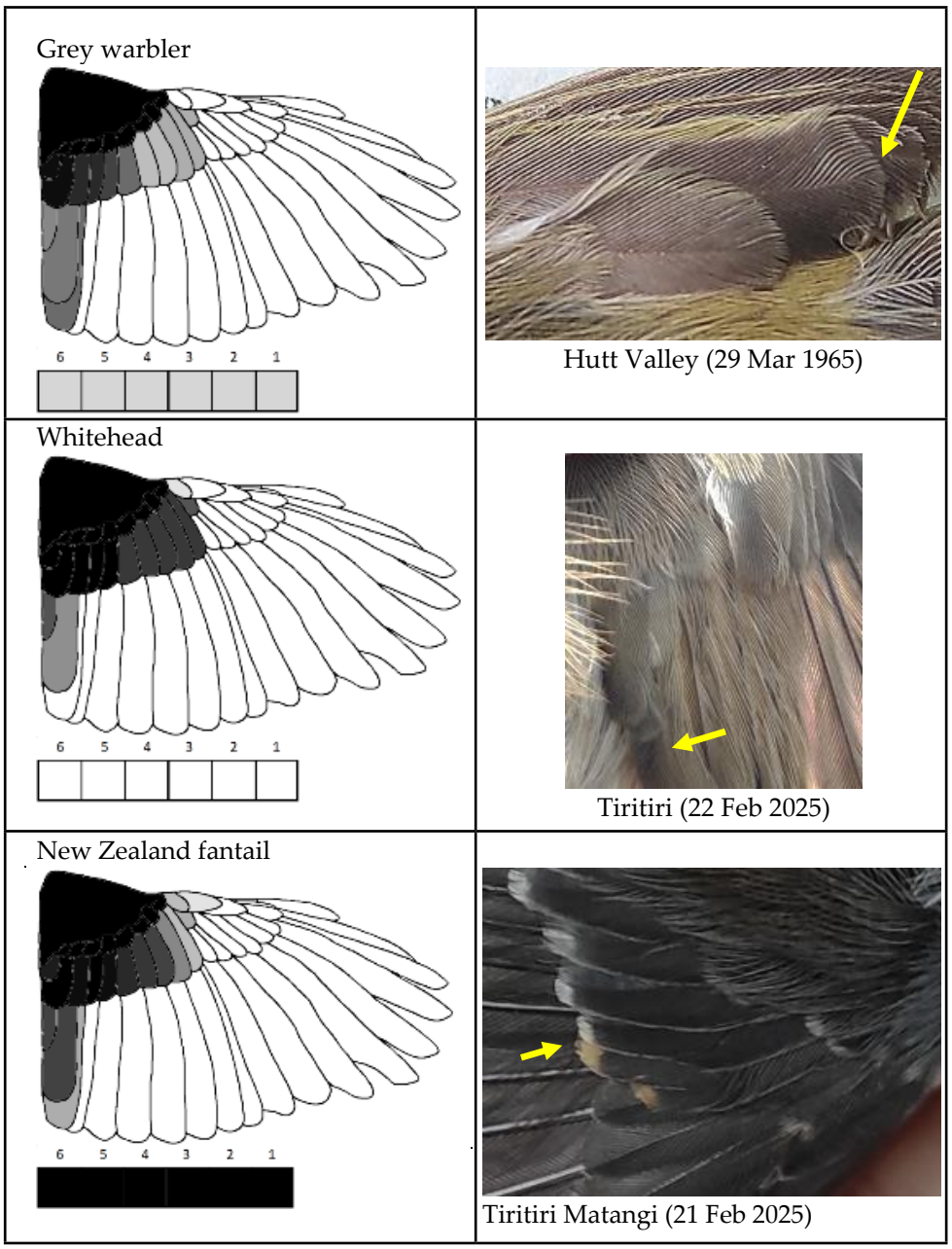


Figure 6. Feather replacement frequency in the post-juvenile moult of grey warbler, whitehead, and New Zealand fantail. Left column: Frequency of wing-feather replacement (top diagram) and of rectrix replacement (bottom squares). Grey shades depict observed percentage of replacement (white = 0%, black = 100%). Right column: Examples of moult limits (indicated by yellow arrows) with localities and dates. Photos by authors.

New Zealand pipit pīhoihoi: the juvenile plumage was paler overall with whitish margins to wing feathers that contrasted with the rufous margins of adults. Post-juvenile moult-limits were found within greater coverts (30 of 31 birds) and tertials (27 of 31 ones (Fig. 11). Pre-breeding moult limits were found within greater coverts and tertials also, with strong contrast between the fresh new feathers and the very deteriorated retained ones (Fig. 11). Age determination after the pre-breeding moult should rely on the shape and wear of feathers and not on the presence of moult limits (Jenni & Winkler 2020a).

DISCUSSION

Moult extent and pattern

Some New Zealand passerines show noticeable within-species differences in post-juvenile moult-extent (e.g., bellbirds moult from 11 up to 42 wing feathers; Guallar *et al.* 2025; Table 3). Considering that hatching date is negatively correlated with moult-extent (Bojarinova *et al.* 1999), this variation could be largely explained by the span of the breeding period. Moult extent is known to affect the social life of passerines because first-year males with larger post-juvenile moult-extent receive more aggression from adult ones, and this can have fitness consequences as seen in North Island robins (Berggren *et al.* 2004; Senar 2006). In this sense, the effect of post-juvenile moult-extent on the social life of the two Meliphagidae species of New Zealand merits further study, particularly how acquisition of notched primaries affects interactions with adults, winter survival, and mate selection in relation to changes in environmental conditions over the years (Craig 1984; Senar *et al* 1998, López *et al.* 2005).

Post-juvenile moult-extent estimates for four New Zealand passerines were obtained from very small sample sizes and should be taken with caution

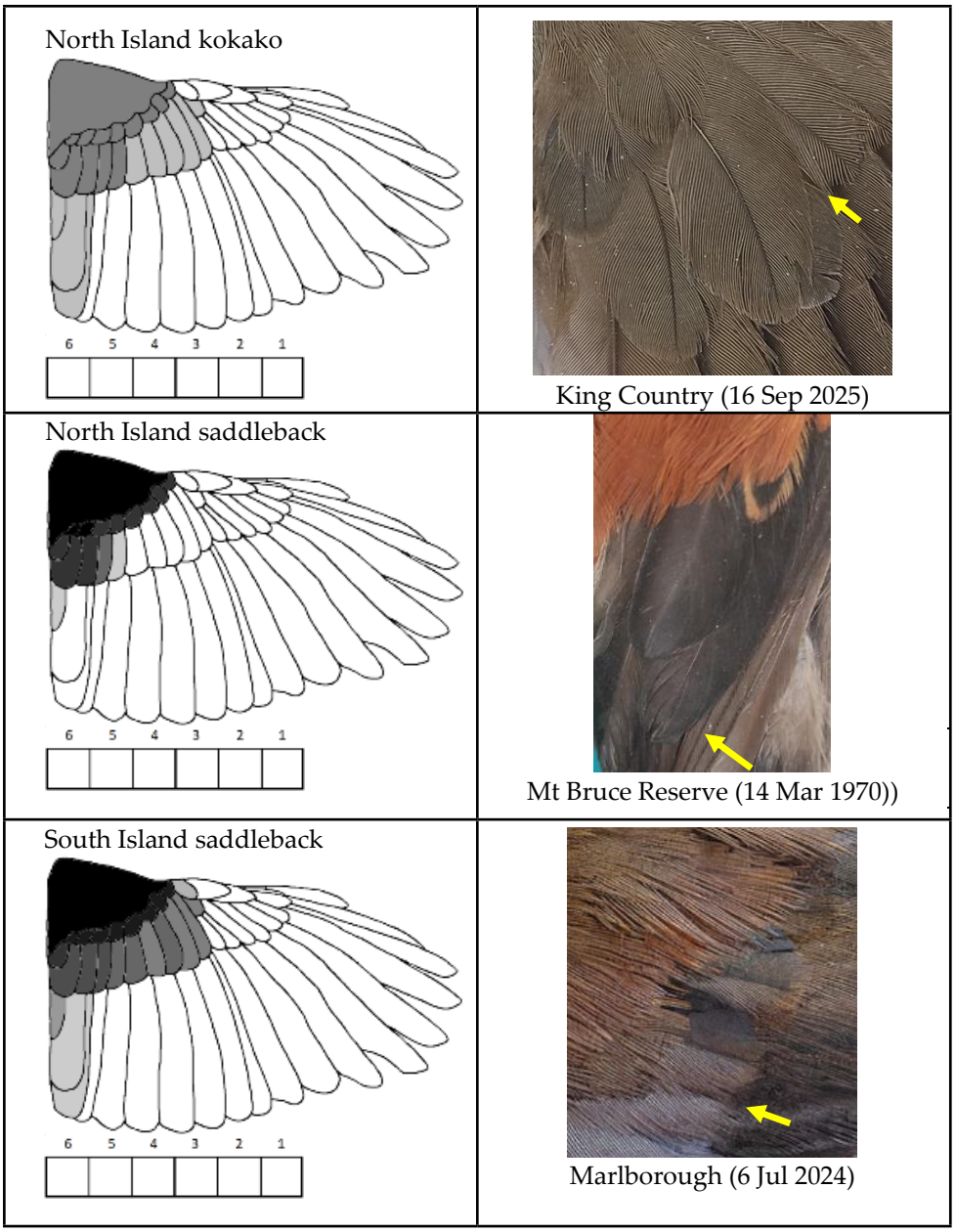


Figure 7. Feather replacement frequency in the post-juvenile moult of New Zealand wattlebirds. Left column: Frequency of wing-feather replacement (top diagram) and of rectrix replacement (bottom squares). Grey shades depict observed percentage of replacement (white = 0%, black = 100%). Right column: Examples of moult limits (indicated by yellow arrows) with localities and dates. Saddleback photos used by license agreement from the Macaulay Library; kokako photo by authors.

(Table 3; McCarthy 2007). However, comparison with the scarce information published on the post-juvenile moult of their closest relatives show clear similarities. For example, a portion of New Holland honeyeaters *Phylidonyris novaehollandiae* (Meliphagidae) exhibit an eccentric pattern, while the regent honeyeater *Anthochaera phrygia* undergoes a partial moult (Paton 1982; Munro & McFadden 2005). Grey warbler's congeners also undergo a partial moult (Higgins & Peter 2002). Like New Zealand fantail, the rufous fantail *Rhipidura rufifrons* retains greater coverts (Radley *et al.* 2011). Petroicidae species apparently undergo a partial moult (Higgins & Peter 2002). Welcome swallow's and silvereye's congeners also undergo a complete moult (Melville 1988; Radley *et al.* 2011). Incidentally, both species colonised New Zealand in recent times (Higgins & Peter 2002). Welcome swallow also shows the typical moult suspension of species in the family Hirundinidae (Niles 1972; Wilson *et al.* 2006). New Zealand pipit's congeners exhibit similar moult patterns (Guallar & Figuerola 2016), and is the only species in which we detected a pre-breeding moult. These similarities suggest that, despite their evolution in relative isolation, the post-juvenile moult of New Zealand passerines presents a phylogenetic inertia, in accordance with studies based on larger avifaunas (Delhey *et al.* 2020; Guallar & Jovani 2020a).

Low sample sizes may have also prevented detection of infrequent or occasional wing-feather moult patterns across New Zealand passerines. For example, we did not observe any partial post-juvenile moult in silvereye, as seen in Australia for birds hatched at the end of the breeding season (Swanson 1971; Scott *et al.* 2023). As found in previous studies, 'General' is the commonest post-juvenile moult-pattern (Table 2), while the inverted and reduced ones are associated with the pre-breeding moult (Guallar *et al.* 2018, 2020; Guallar & Jovani 2020a). The biological meaning of post-juvenile moult-pattern variation within species is unclear (Guallar *et al.* 2014).

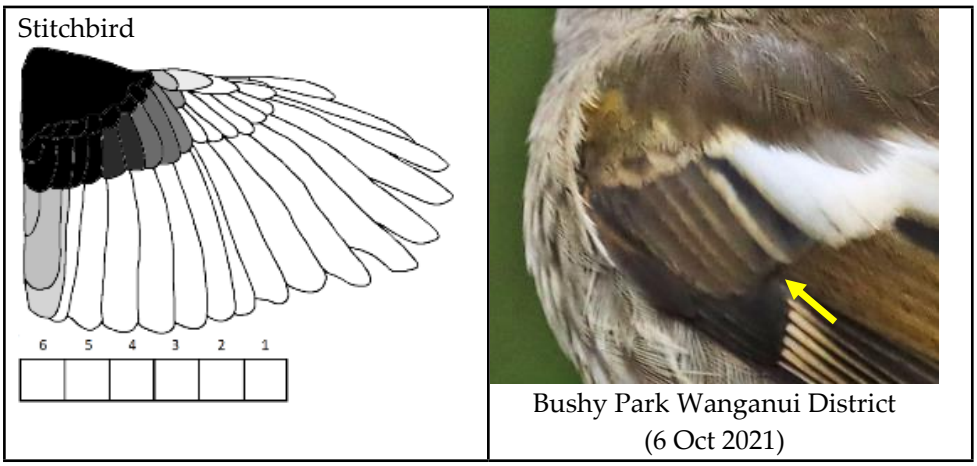


Figure 8. Feather replacement frequency in the post-juvenile moult of stitchbird. Left column: Frequency of wing-feather replacement (top diagram) and of rectrix replacement (bottom squares). Grey shades depict observed percentage of replacement (white = 0%, black = 100%). Right column: Examples of moult limits (indicated by yellow arrows) with localities and dates. Photo used by license agreement from the Macaulay Library.

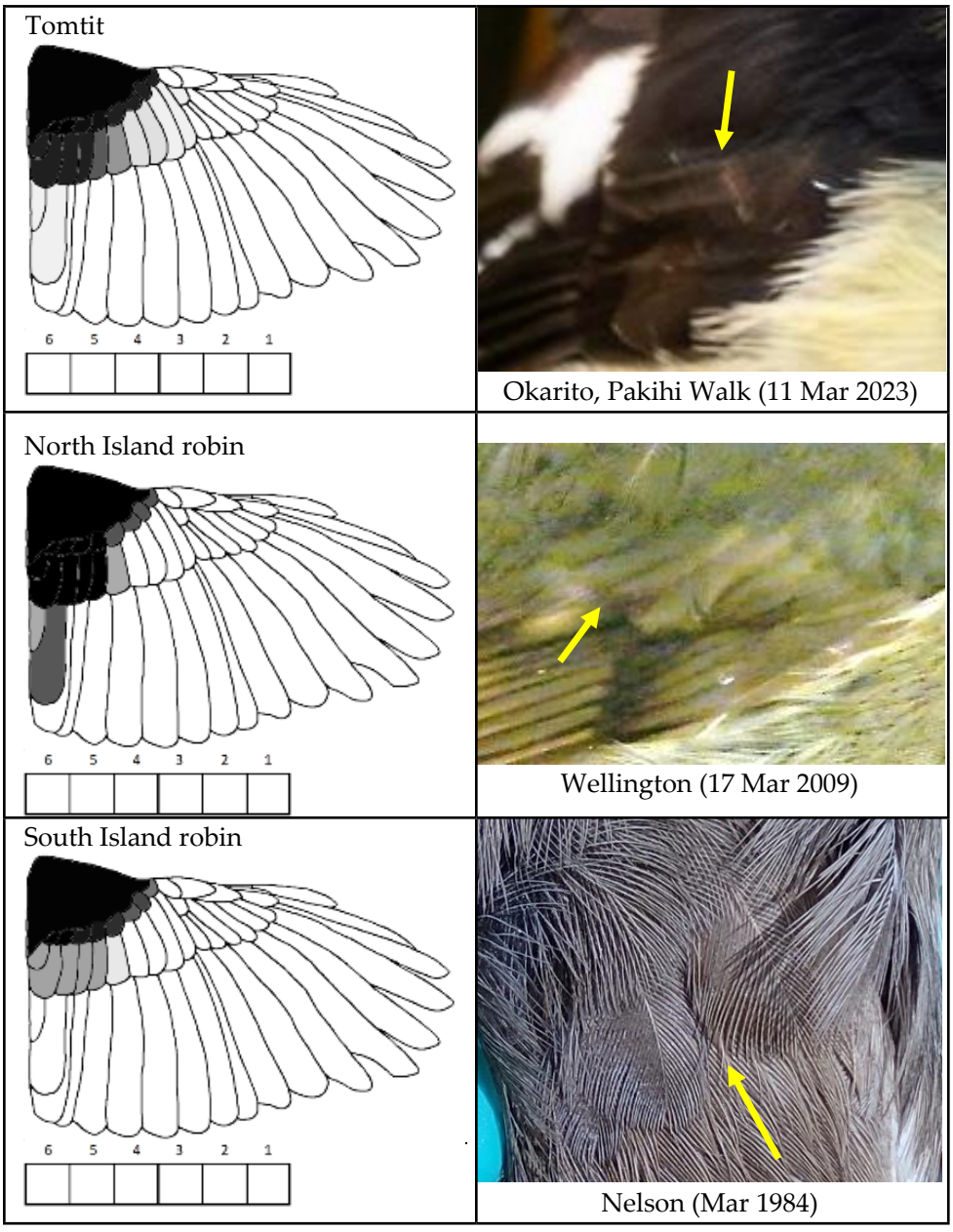


Figure 9. Feather replacement frequency in the post-juvenile moult of New Zealand robins. Left column: Frequency of wing-feather replacement (top diagram) and of rectrix replacement (bottom squares). Grey shades depict observed percentage of replacement (white = 0%, black = 100%). Right column: Examples of moult limits (indicated by yellow arrows) with localities and dates. Photos used by license agreement from the Macaulay Library.

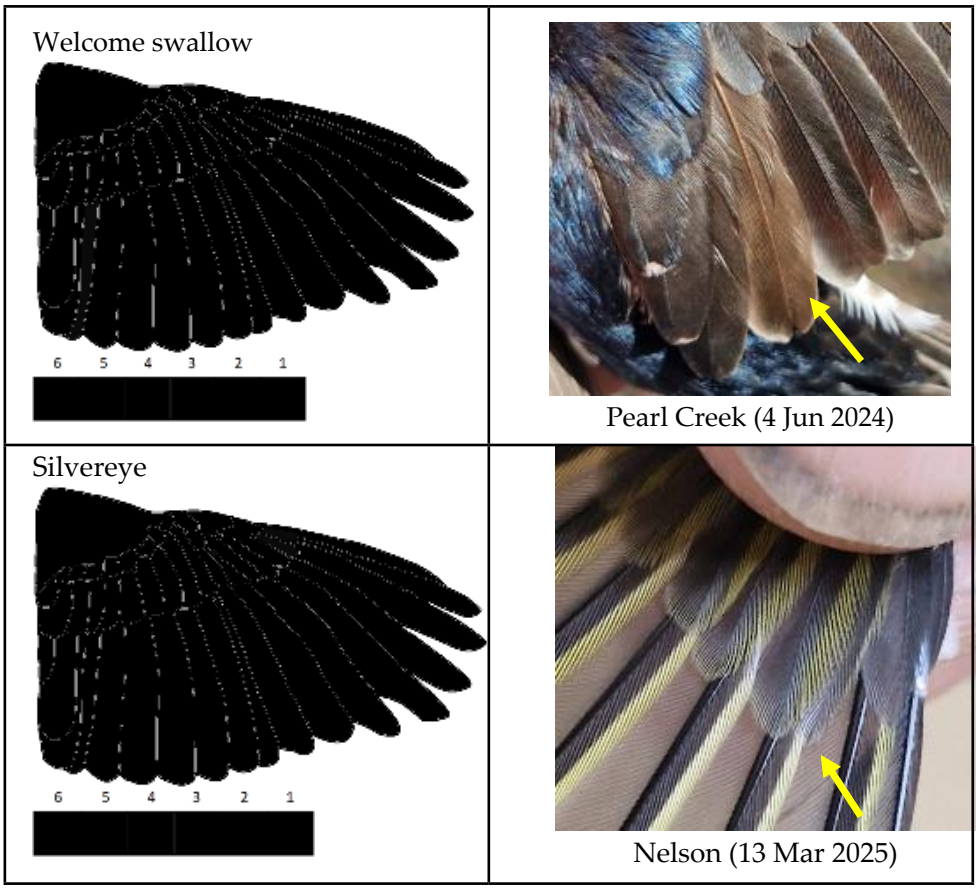


Figure 10. Feather replacement frequency in the post-juvenile moult of welcome swallow and silvereye. Left column: Frequency of wing-feather replacement (top diagram) and of rectrix replacement (bottom squares). Grey shades depict observed percentage of replacement (white = 0%, black = 100%). Right column: Examples of moult limits (indicated by yellow arrows) with localities and dates. Photos by authors.

However, moult patterns suggest that the feathers finally replaced during the post-juvenile moult are controlled by rules that balance moult extent increases with the general needs and constraints of each species (Barta *et al.* 2008; Guallar & Jovani 2020b; Guallar 2024). For example, increase in the post-juvenile moult-extent of bellbirds prioritises outer (notched) primaries over rectrices, whereas New Zealand pipits prioritise tertials and even rectrices over outer greater coverts (Fig. 4).

Age determination

Accurate age determination demands integrative use of morphological information. Timing within the annual cycle determines how to carry out this task, implying that the ageing guidelines may differ before, during, and after the moulting season. Differences in appearance between the adult and the juvenile should be used throughout the whole first annual cycle, albeit their applicability diminishes as the bird passes through new stages of the annual cycle. Indeed, these differences blur in the moulting season as the juvenile plumage gets replaced, during which moult sequence becomes diagnostic to distinguish between partial and complete moults. Once moult is finished, differences in appearance between the adult and the juvenile are at its minimum, and once unfeathered characters are fully mature, moult limits become the only guideline left (provided that the post-juvenile moult is not complete).

Technological advances may allow ageing of long-lived birds throughout their life time with a small error (De Paoli-Iseppi *et al.* 2019; Roman *et al.* 2024); however, age determination of birds in the field currently relies entirely on human assessment (although see Weidensaul *et al.* 2011). We caution that insufficient experience or training may lead to too much weight to morphological traits considered to be age diagnostic, without critical appraisal. For example, adult but not juvenile outer primaries of tui and bellbird have pronounced notches (Onley 1986; Bartle & Sagar 1987). If this character is used *prima facie*, without assessing moult limits, about 15% first-cycle tuis and 60% first-cycle bellbirds would be incorrectly classified as adults (Table 3). Similarly, about 25% first-cycle New Zealand fantails moulting all greater coverts would be incorrectly classified as adults if age determination relied solely on the presence of tawny tips on the greater coverts (Table 3; Radley *et al.* 2011). Conclusions from any analysis based on data obtained from this method would be incorrect. This is potentially relevant for managing New Zealand passerine populations, given that the success of translocations can be influenced by the age of the released birds, with young birds being more likely to settle, survive, and breed in the translocated areas (Miller *et al.* 2024; Morkvėnas *et al.* 2025).

Our results cover an important gap in the knowledge of the natural history of New Zealand passerines, generate reliable age determination criteria, and provide essential information to test hypotheses on the ecology and evolution of avian moult in the Australasian region. Nevertheless, since some of our findings are based on a very low sample size, we encourage New Zealand ornithologists and bird banders to accrue more moult information, both quantitative and photographic, and to refine the ageing criteria here outlined with larger sample sizes and more comprehensive descriptions.

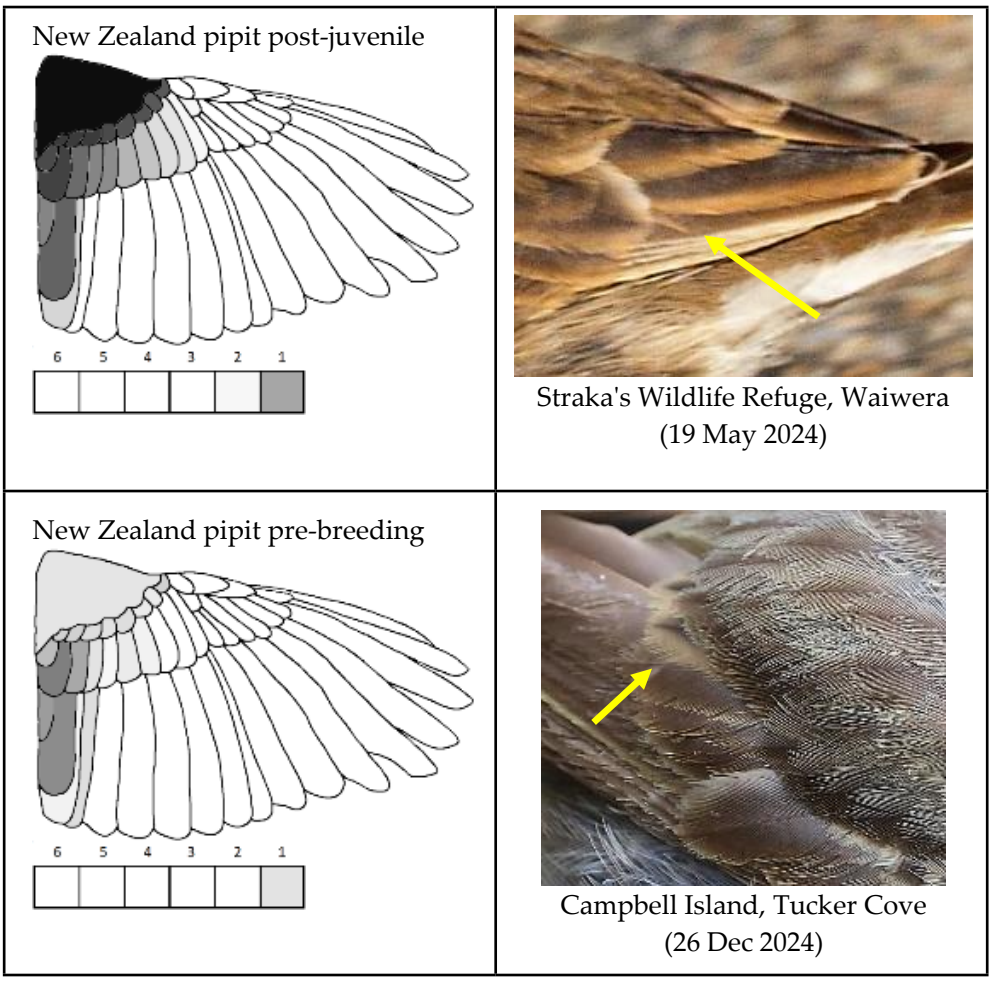


Figure 11. Feather replacement frequency in the post-juvenile and pre-breeding moults of New Zealand pipits. Left column: Frequency of wing-feather replacement (top diagram) and of rectrix replacement (bottom squares). Grey shades depict observed percentage of replacement (white = 0%, black = 100%). Right column: Examples of moult limits (indicated by yellow arrows) with localities and dates. Photos used by license agreement from the Macaulay Library.

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ETHICS

Mist-netting and banding were undertaken under the Ornithological Society of New Zealand's Wildlife Act Authorisation 48320-FAU issued by the Department of Conservation.

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New insights into the behavioural ecology of the Pacific imperial pigeon (*Ducula pacifica*)

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Abstract: Pacific imperial pigeons (*Ducula pacifica*) are important seed dispersers with complex vocal and behavioural repertoires. This study documents their vocalisations, territoriality, mating, nesting, and feeding behaviours in Rarotonga, Cook Islands. Five vocalisation types were identified and described here as the *common coo*, *territorial coo*, *courtship coo*, *quiet coo*, and *growl*. The *common coo* and *growl* were most frequent, often exchanged in call-and-response between distant birds. The *territorial coo* and *courtship coo* were linked to close interactions. Territoriality involved displays, chasing, and occasional combat. Year-round aerial display flights suggest a potential role in territoriality rather than being exclusively tied to breeding season. Mating included novel post-mating courtship feeding. Feeding observations and faecal analyses confirmed an exclusive reliance on non-native plants, indicating a potential role in spreading invasive species. This study enhances knowledge of Pacific imperial pigeon vocalisations and behaviours, with implications for species identification, invasive species management, and habitat maintenance and restoration in Pacific ecosystems.

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INTRODUCTION

Pacific imperial pigeons (*Ducula pacifica*) are large, frugivorous pigeons native to islands across the southern Pacific Ocean, ranging from the Bismarck and Louisiade Archipelagos in Papua New Guinea in the west to the Cook Islands in the east (Holyoak & Thibault 1984; Pratt *et al.* 1987; Baptista *et al.* 2020a). These birds play a crucial ecological role as seed dispersers of native vegetation, contribute to the maintenance and regeneration of tropical forests, and serve as a food source for local communities throughout their range (Beichle 1991; McConkey *et al*. 2004; Meehan *et al.* 2005; Powlesland *et al*. 2008; Pratt & Mittermeier 2016; Serra 2016; Serra *et al.* 2021).

Pacific imperial pigeons inhabit diverse tropical ecosystems, from low-lying atolls to high inland forests, and are exclusively arboreal (Holyoak & Thibault 1984). Their diet reportedly includes young leaves, flowers, and primarily dozens of species of tree fruits, and they often congregate in large feeding groups (Beichle 1991; Watling 2001; McConkey *et al.* 2004; Serra 2016; Baptista *et al.* 2020a). Fruit seeds smaller than 20 mm are typically defecated, while larger seeds are reportedly regurgitated, both in viable conditions that promote germination (McConkey *et al.* 2004). Although most seeds are voided near host trees, dispersal distances of up to 100 km are theoretically possible (McConkey *et al.* 2004).

Direct observations of Pacific imperial pigeons are challenging, with calls and dietary habits often recorded without visual confirmation, complicating species differentiation (Holyoak & Thibault 1984; McConkey *et al.* 2004; Pratt & Mittermeier 2016). Currently, their vocalisations are classified into two categories: growls, which are species-specific, and coos, which are less distinctive (Beichle 1991; Pratt & Mittermeier 2016).

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A regular repeating coo call attributed to Pacific imperial pigeons by Beichle (1991) was attributed to the tooth-billed pigeon (*Didunculus strigirostris*) by Pratt & Mittermeier (2016) and Serra *et al.* (2021). Confusion between calls may have inflated population estimates of tooth-billed pigeons (Pratt & Mittermeier 2016).

Little is known about the nesting or mating behaviours of Pacific imperial pigeons, with no information on nesting season from the Cook Islands. They construct nests made of twigs high in trees and both parents participate in incubation of a clutch of one or possibly two eggs (Holyoak & Thibault 1984; Baptista *et al*. 2020a). In American Samoa, nesting is mainly from May to August; in Tonga, fledglings are most common from January to February. In Vanuatu, nests are most common from September to January (Gibbs *et al.* 2001). Birds are also known to perform display flights believed to correlate with breeding, though these flights remain undescribed (Powlesland *et al.* 2008; Butler 2012).

Historically inhabiting native interior forests of Rarotonga, Cook Islands, Pacific imperial pigeons began expanding into coastal regions in the late 1980s, lured by the planting of non-native Manila palms (*Adonidia merrillii*) with edible fruits (Turbott 1977; G. McCormack, pers. comm., 2023). In Rarotonga, these birds coexist with the endemic Cook Islands fruit-dove (*Ptilinopus rarotongensis*), the only other extant native columbid (Holyoak & Thibault 1984; Turbott 1977). Pacific imperial pigeons in the Cook Islands consume fruits of *Ficus* spp., Tahitian chestnut (*Inocarpus fagifer*), beach gardenia (*Guettarda speciosa*), and others, with fruit sizes ranging from 3–30 mm in diameter, though their extensive use of recently introduced plant species is unpublished (Holyoak & Thibault 1984; Staddon *et al*. 2010; G. McCormack, pers. comm. 2025).

This study provides a comprehensive description of the calls and behaviours of Pacific imperial pigeons via direct observation in the Cook Islands. It is the first account of behaviour of Pacific imperial pigeon from the Cook Islands in nearly 50 years. The findings provide new insights into previously undescribed aspects of their ecology, including specific vocalisations, diet, territoriality, display flights, mating, and nesting behaviour. Understanding the vocalisations of Pacific imperial pigeons is critical for distinguishing them from co-occurring species and improving population estimates, which are required for monitoring and conservation in the Cook Islands and other regions. Knowledge of their breeding seasons is vital for sustainable hunting management, enabling the protection of breeding individuals. Insights into their diet highlight contributions to seed dispersal, forest health, and ecosystem maintenance.

MATERIALS AND METHODS

Observations of Pacific imperial pigeon behaviour were made by the author in Tikioki, Rarotonga, Cook Islands (21.2654°S 159.7420°W) from July 2023 to June 2024. The study site was a ~5000 m^2 section of lowland area composed of non-native vegetation. Monitoring was performed during daylight hours, with 10–20 hours of direct observation each month.

All observations, including those of vocalisations and defecations were made exclusively on visually identified birds. Seeds found in faeces were measured and identified to the lowest possible taxonomic level.

Nest investigations were made by video using an iPhone X attached to the end of a 5 m pole. Videos of territorial behaviour were made with the same device. Photographs of birds were taken with a Sony a7RV with a Sony FE 100-400 lens. Sonograms were extracted from video recordings, and both sonograms and videos were archived in the Macaulay Library of the Cornell Lab or Ornithology, where they are publicly accessible (https://www.macaulaylibrary.org). Video and sonogram catalog numbers begin with 'ML'.

RESULTS

Vocalisations and associated posturing

Vocalisations were categorized into two main types: coos and growls. Using observations of call-associated posturing, time between vocalisations, and numbers of birds present during vocalisation, the coos were further subdivided into four distinct variations: *common coo*, *courtship coo*, *territorial coo*, and *quiet coo* (Table 1). The most frequent vocalisations were the *common coo* and the *growl*, with birds loudly vocalising over many minutes, and often switching back and forth between the two calls. Both the *common coo* and *growl* were used as a call-and-response, including by incubating birds, with distant birds sometimes replying. When together, mated pairs were almost always silent, except in rare cases when making the *courtship coo* or *territorial coo*. The least common vocalisations were the *quiet coo* and *courtship coo*.

Common coo

The *common coo* consisted of two or three slurred notes. Most frequent variations included a two-note, descending *OOOooh*, a three-note ascending then descending *oooOOOooh*, and a two-note ascending *oooOOH*. Occasionally, this call had a preceding element with a brief pause, followed by a louder, higher-pitched note, *hoo-OOH*. Within these variations, individual calls varied further in pitch and volume. The *common coo* was made only by solitary birds. Pauses between each call were longer than the call itself.

When calling, birds stood tall with their heads angled downward and their chests inflated (Fig. 1; ML632007918). There was minimal body movement; the head bowed slightly, and in some instances, the tail lowered during the call. After each call, birds returned to their normal posture and scanned their surroundings. The *common coo* was sometimes interspaced with the *growl* (described below).

Figure 1. Body posture of Pacific imperial pigeon (*Ducula pacifica*) during *common coo* vocalisation.

Territorial coo
The *territorial coo* consisted of one to three gentle *ooohs* separated by pauses roughly equal to the length of each note: *oooh*-pause-*oooh*, or *oooh*-pause-*oooh*-pause-*oooh* (ML632007821, ML640212799). Notes and pauses between notes were approximately one second. This call was accompanied by territorial posturing in which the bird stood tall with head pulled back and bill pressed against inflated chest (Fig. 2a), then quickly dropped into a crouched position with head facing downward (Fig. 2b). A single *oooh* was uttered during the crouch, followed by a return to the upright posture and usually repeating the whole sequence two or three times.

Figure 2 (a). Pacific imperial pigeon (*Ducula pacifica*) in upright body posture and (**b).** crouched body posture during *territorial coo* vocalisation and display.

Courtship coo
The *courtship coo* was a series of six to ten progressively shorter *ooohs* with a quick stop between each: *ooooh-ooooh-oooh-oooh-ooh-oh-oh-oh-oh-oh*. Vocalising birds bobbed their heads with each *oooh*, and occasionally the bobbing caused birds to bounce, particularly when perched on thinner branches. This call was usually made once but was occasionally repeated a second time. It was always directed by one bird towards a nearby bird that appeared to be its mate.

Quiet coo
The *quiet coo* had a distinctive windy tone, a lower volume compared to the *common coo*, and usually a single variation: *oooOOOooh* (sometimes *hoo-OOOooh* interspaced). Birds making this call typically had their eyes closed, producing the sound with minimal body movement, and, unlike those making the *common coo*, they would not look around after each call. The *quiet coo* was repeated at regular intervals over many minutes.

Growl
The *growl* was like the common coo but with a trilling overlay. The pitch and speed varied greatly, ranging from a deep, trilling *hooo* to a high-pitched *gr-r-r-r* growl. Most common calls were *GR-R-R-r-r-r-r* and *gr-r-r-R-R-R-r-r-r* (ML632007480). Occasionally, this call was preceded by a short element: *grrr-ROOO*. Birds produced *growls* with heads facing forward or tilted slightly upward, throats expanded, and neck and throat feathers irregularly erected (Fig. 3). Birds only made these calls when they were alone, and often immediately upon landing. Pauses between each call were longer than the call itself.

Figure 3. Pacific imperial pigeon (*Ducula pacifica*) body posture during growl vocalisation.

Territoriality
Birds exhibited strong territoriality, with aggressive behaviour directed towards other Pacific imperial pigeons, except for their mates. Birds were never observed in large flocks, despite substantial availability of palm fruits. No more than two birds (a mated pair) were observed peacefully together at any one time.

Territoriality followed a three-stage escalation: (1) approaching, (2) approaching and territorial display, and (3) approaching, territorial display, and attack and/or combat.

Upon observing another bird or mated pair, a dominant bird flew or hopped through foliage to approach the other(s). This often prompted the others to flee the area.

Table 1. Descriptions of Pacific imperial pigeon (*Ducula pacifica*) vocalisations.

Vocalisation	Description	Sound	Volume	Birds present during call
Common coo	Single or repeated at irregular intervals of many seconds to minutes	*OOOooh*, *oooOOOooh*, or *oooOOH* Infrequently: *hoo-OOH*	Quiet to loud	One
Courtship coo	Produced once or twice in succession	*ooooh-ooooh-oooh-oooh-ooh-oh-oh-oh-oh-oh*	Medium	Two
Territorial coo	Produced once or twice in succession	*oooh*, *oooh*-pause-*oooh*, or *oooh*-pause-*oooh*-pause-*oooh*	Quiet	Two-Four
Quiet coo	Windy tone, repeated at regular intervals	*oooOOOooh* Infrequently: *hoo-OOOooh*	Quiet	One
Growl	Single or repeated at irregular intervals of many seconds to minutes	*GR-R-R-r-r-r-r*, or *gr-r-r-R-R-R-r-r-r* Infrequently: *grrr-ROOO*	Quiet to loud	One

If the approach by the aggressor failed to drive the bird(s) away, the aggressive bird performed a territorial display (i.e., *territorial coo* and posturing). Frequently, a single territorial display was sufficient to cause the other bird(s) to retreat.

Occasionally, an opponent responded by attacking the displaying bird, or by maintaining its position and performing a counter-display. Counter-displaying birds hopped between branches and rotated positions until one bird attacked the other. This attack was always directed toward a bird that was mid display.

During an attack, the aggressor attempted to land on the opponent while biting and flapping wildly. Most attacks caused the opponent to retreat to a lower branch or fly away without physical contact. If the altercation continued, birds returned to the original branches and resumed displays. Some attacks resulted in both birds clutching each other and falling more than 2 m to the ground. Another attack resulted in two birds colliding while flapping violently, which led to a brief pause with one bird hanging upside down from a branch while holding the other bird in its beak.

Display flight

Aerial displays were observed throughout the year, sometimes multiple times per day. A single displaying bird took flight, flapped forcefully in a downward swoop with wings sometimes clapping together, before angling into an upward arc approximately 5-8 m high. As the flight path became vertical, the bird paused momentarily before it dived and levelled into normal flight (Fig. 4; ML632007227). Only one aerial display typically occurred per flight, though occasionally two sequential displays were performed. No vocalisations were observed during display flights.

Mating and courtship feeding

Mating was observed on 21 Dec 2023. Two birds sat side-by-side, and the female crouched and presented a horizontal back. She remained crouched in this position for 47 seconds until the male mounted her (Fig. 5a). Mating lasted 9 seconds. After dismounting, the female remained crouched and arched her head upward toward the male in a begging posture. The male responded by feeding the female for approximately 4 seconds (Fig. 5b). Following this, the pair separated and groomed. No vocalisations were observed.

Nesting

A nest was observed on 31 Mar 2024, located approximately 6 m above the ground in a weeping fig tree (*Ficus benjamina*). At first observation, the nest was fully constructed, and adult birds appeared to take turns incubating egg(s) or young. The nest was rarely left unattended. Incubating birds generally remained still and silent but occasionally modified the nest and performed common coo and growl calls.

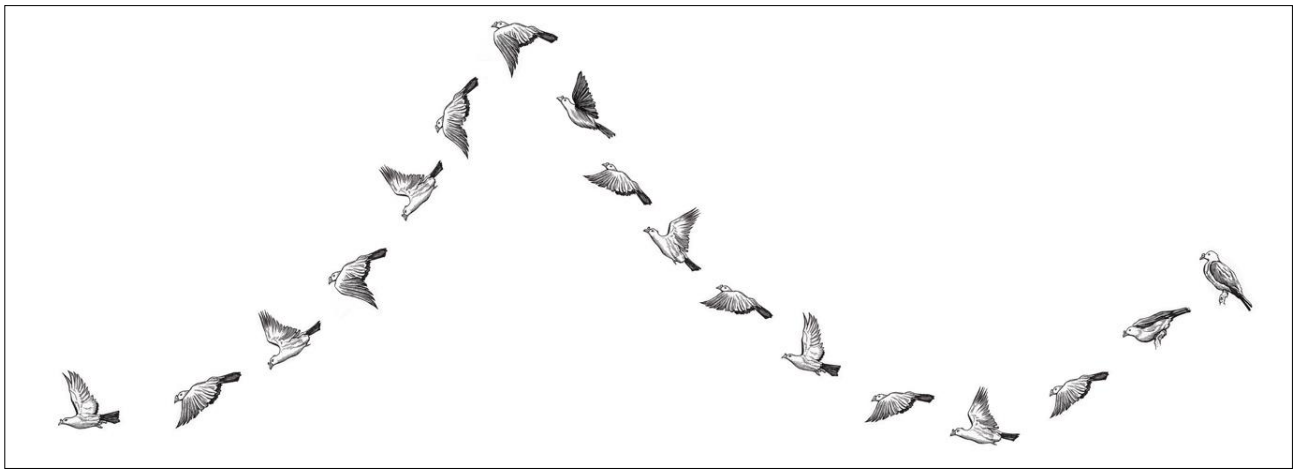

Figure 4. Display flight of the Pacific imperial pigeon (*Ducula pacifica*). Note: Bird and display flight not to scale. Illustration by Jeremy Bennett.

Figures 5 (a). Pacific imperial pigeon (*Ducula pacifica*) mating and **(b).** post-mating courtship feeding (male on right).

Attempts to film the egg(s)/young were unsuccessful. When approached with a pole camera, the incubating bird postured by raising one wing vertically (Fig. 6; ML632007650) but always remained on the nest, blocking the view. Last observations of the active nest were on 19 April. When observations resumed on 14 May, the nest was vacated or abandoned.

Figure 6. Nest guarding by incubating Pacific imperial pigeon (*Ducula pacifica*).

A fledged juvenile was observed nearby on 26 May. The juvenile had a small cere, remnant down feathers, and brown irises, unlike the red irises of adults (Fig. 7). The juvenile approached a pair of adult birds and was chased away.

Figure 7. Juvenile Pacific imperial pigeon (*Ducula pacifica*) with small cere, brown eye and remnant down.

Feeding, drinking; faecal examination

Birds were observed feeding on fruits of areca palm (*Areca triandra*), Fiji fan palm (*Pritchardia pacifica*), Macarthur palm (*Ptychosperma macarthurii*), white mulberry (*Morus alba*), and flowers of ice-cream bean (*Inga edulis*). They were also observed on the ground consuming small particles from the ground. Birds drank rainwater from leaf surfaces and from small puddles on the ground.

Thirty-five faecal specimens from defecating birds were recovered and analysed. Faeces were primarily composed of seeds and fruit skins suspended in a thick mucus. Seeds were identified as *Capsicum* sp., Manila palm (*Adonidia merrillii*), and areca palm. Faeces with Manila palm seeds contained only a single seed coated in a thin layer of mucous. The largest excreted Manila palm seed measured 19 mm wide by 31 mm long. No observations of regurgitations were made.

DISCUSSION

This study provides new insights into the vocalisations, behaviours, and ecological roles of Pacific imperial pigeons in the unique context of Rarotonga, Cook Islands by describing previously unreported vocalisations and their associated behaviours. Moreover, observations of feeding behaviours and seed dispersal patterns shed light on the pigeon's relationships with both native and non-native plant species. These findings have broader implications for columbid ecology and conservation strategies, and the management of native and invasive plant populations.

Coo and growl vocalisations have been well documented by other authors by both visual and inferred investigation (Holyoak & Thibault 1984; Beichle 1991; Pratt & Mittermeier 2016; Baumann & Beichle 2020). However, this study describes two new coo variations (the *territorial coo* and the *courtship coo*) and associated behaviour during calls. For instance, the *common coo*, *quiet coo*, and *growl* were only made by individual birds when they were alone. The *courtship coo* and *territorial coo* were only made when birds were in the presence of others. This pattern held up in reverse – when birds were first heard rather than seen, their calls always indicated how many other birds were in the immediate area. These results may allow observers to estimate how many unsighted birds are present based on the calls heard.

The *quiet coo* was most similar to the *common coo*, but was differentiated by volume, call-associated behaviour and duration of repetition. Observations of the *quiet coo* being repeated over many minutes supports those made by Beichle (1991). However, Beichle (1991) classified this as a 'territorial coo'. Rarotonga birds that made this call over many minutes appeared uninterested in a response, because after each call, they did not scan their surroundings as they did during the *common coo*. Instead, they sat nearly motionless, often with their eyes closed, and did not seem to be claiming territory or warning off rivals.

Pratt & Mittermeier (2016) noted that "An important difference is that a series of moans from a Pacific imperial pigeon usually varies in both pattern and cadence, and almost always include some growls if the sequence is long enough." These observations were the same for the majority of Rarotonga pigeon vocalisations, except the *quiet coo* that has a regular pattern and cadence and lacks interspaced growls. Pratt & Mittermeier (2016) recorded an unseen bird (ML 139904), thought to be a tooth-billed pigeon rather than a Pacific imperial pigeon. This recording sounds nearly identical to the *quiet coo* from Rarotonga birds. As noted by Baumann & Beichle (2020) though, differentiating between these species in the field is exceedingly difficult, and best done by laboratory analysis of recordings.

Identical descriptions of what was classified in this study as the *territorial coo* and posturing have been described by Forshaw & Cooper (2015) for Christmas Island imperial pigeons (*Ducula whartoni*). However, for Christmas Island imperial pigeons, this behaviour was attributed to courtship rather than aggression. For Pacific imperial pigeons in Rarotonga, however, this display was never directed towards a mate and always used to intimidate or initiate a fight.

Previously in the Cook Islands, calls containing a rapid series of coos (described in this study as the *courtship coo*) were attributed only to Cook Islands fruit-doves (G. McCormack, *pers. comm*., 2024). However, this study found that Pacific imperial pigeons make this vocalisation.

As a result, additional investigations are required to differentiate calls between these two species to aid in population estimates.

Beichle & Baumann (2016) classified the *growl* call into two categories. While this could be true of Rarotonga birds, two distinct categories were not observed, although a specialised audio recorder or software for comparisons might show them. Future studies of Rarotonga birds should include recording devices, as video recordings allow vocalisations to be interpreted as part of behavioural sequences.

Even with substantial stands of fruiting areca palms, Rarotonga Pacific imperial pigeons were extremely territorial and never tolerated the presence of other Pacific imperial pigeons, except for their mates. Large flocks sharing fruiting trees as described by Holyoak & Thibault (1984) and Powlesland *et al.* (2008) were not observed in this study. Territorial behaviour was observed throughout the year, which made it unclear which resources were being guarded. Blanvillain & Thorsen (2003) observed Marquesan imperial pigeons (*Ducula galeata*) exhibiting guarding behaviour in food trees; however, these interactions were limited to chasing. Observations of territorial displays and combat in this study appear to be the first for the genus.

Powlesland *et al.* (2008) noted that display flights of Pacific imperial pigeons could be an indicator of nearby nesting, and Butler (2012) attributed pigeon display flights to the start of breeding season. Display flights are commonly observed in other columbid genera, and in addition to mating season, are also attributed to territoriality (Cramp 1958; Powlesland 2013; Baptista *et al.* 2020b). Pacific imperial pigeons in this study displayed year-round, with no months showing heightened activity, leaving it unclear whether this behaviour serves territorial, mating, and/or other purposes.

Pacific imperial pigeon display flight is like display flights described in other *Ducula* species; however, the number of displays per flight can differ: 1-2 displays per flight by Pacific imperial pigeons from this study, and 3-4 displays per flight by mountain imperial pigeons (*Ducula badia*) (Smythies 1981; Baptista *et al.* 2020b & c; del Hoyo *et al.* 2022).

The single observation of each of mating, nesting, and fledging observed between December and May fell outside the nesting and fledging seasons recorded for Pacific imperial pigeons in American Samoa and Tonga (Baptista *et al.* 2020d) and Vanuatu (Gibbs *et al.* 2001). Based on the limited observations in this study, prohibiting hunting from December to May could provide protection to breeding birds. This date range may apply specifically to Rarotonga; however, additional data on nesting season are needed. Within the Cook Islands, Pacific imperial pigeons are found on multiple islands up to 1,000 km north from Rarotonga, and nesting season may vary (Holyoak & Thibault 1984). Because of the rarity of encountering nests, breeding season might be best determined by extrapolating backwards from emergence of fledged juveniles. Additional hunting management strategies could include a short (2-3 month) hunting season and ammunition limits as employed by the nearby island nation of Niue (Powlesland *et al*. 2008).

Observations of both adults incubating and rarely leaving their loosely made nests of twigs were the same as described by Baptista *et al.* (2020a). Unfortunately, determining the number of eggs or young, and hatching timing was not possible due to nest guarding by the incubating adults.

Courtship feeding, a behaviour observed in various bird families including Columbidae, has not been documented in *Ducula* species prior to this study (Lack 1940; Smith 1980). In wood pigeons (*Columba livia*), males feed females before mating (Lack 1940), contrasting with the post-mating courtship feeding observed in this study. Although Blanvillain & Thorsen (2003) documented mating in the Marquesan imperial pigeon, they did not report any associated courtship feeding. Overall, observations of *Ducula* mating behaviours in the scientific literature are limited.

Birds in this study consumed fruits and flowers and defecated seeds from only non-native species; none of these food sources have been previously reported for Pacific imperial pigeons (Holyoak & Thibault 1984; Beichle 1991; Watling 2001; McConkey *et al*. 2004; Serra 2016; Baptista *et al*. 2020a). The study site was dominated by non-native vegetation and located more than 50 m from the nearest native vegetation. McConkey *et al.* (2004) and Meehan *et al.* (2005) reported that nearly all seeds consumed by Pacific imperial pigeons were voided within 50 m of the trees where the fruits were eaten. Given this context and the small faecal sample size (n=35) in this study, it is not surprising that native seeds were absent. Unlike observations reported by McConkey *et al.* (2004), the birds were never observed to regurgitate seeds during this study. Even the largest seeds, such as those of the Manila palm, were defecated.

Seeds of *Capsicum* sp. and Manila palm were found in faeces, despite neither plant species being present within the study area. This indicates that these seeds were transported, although it is unclear whether they originated within 50 m of the study site. *Capsicum* sp. seeds likely came from the small, non-native, naturalised chili pepper, *Capsicum frutescens*, which is widespread on Rarotonga and commonly consumed by introduced species such as the common myna (*Acridotheres tristis*) and feral chicken (*Gallus gallus*) (*pers. obs*., 2017).

Birds can disperse non-native plant species, contributing to their invasive potential (Aslan 2011). Among the plant species recorded in this study, only the Manila palm is considered invasive in some areas outside its native range, though its invasiveness potential is unknown in the Cook Islands (Connor 2008; Smith 2010; Oviedo & González-Olivia 2015). The Pacific imperial pigeon has been observed feeding on non-native strawberry guava (*Psidium cattleyanum*), contributing to its spread in the native forests of Rarotonga (G. McCormack, *pers. comm*. 2025). Interestingly, although the native Pacific banyan (*Ficus prolixa*) in Rarotonga is found exclusively in lowland non-native forests, Pacific imperial pigeons do not frequent it or disperse its seeds, despite seed dispersal of these species by Pacific imperial pigeons elsewhere (Compton & McCormack 1999; Staddon *et al*. 2010). Vegetation surveys in Rarotonga's inland forests could help determine whether viable Manila palm or other non-native seeds are being transported and germinating, as well as their potential impact on native forests.

The direct observations and faecal analyses in this study, while limited, raise key questions regarding the movement patterns and feeding preferences of Pacific imperial pigeons in Rarotonga. It remains unclear whether the birds observed in this study are primarily residents of lowland areas dominated by non-native vegetation, if they move between lowland and native forests but preferentially feed on non-native fruits, or if they feed in both areas, but with seeds primarily voided near their respective fruiting trees, as per McConkey *et al.* (2004) and Meehan *et al.* (2005).

Future research should focus on the role of Pacific imperial pigeons as seed dispersers for both native and non-native plants in order to assess their impact on native ecosystems. Additionally, studies on seed dispersal and viability for the Mitiaro fan palm and other native plants in the Cook Islands would deepen the understanding of the ecological roles once fulfilled by bird species, offering valuable guidance for conservation strategies.

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Vagrant and extra-limital bird records accepted by the Birds New Zealand Records Appraisal Committee 2023–2024

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Abstract: We report Records Appraisal Committee (RAC) decisions regarding Unusual Bird Reports received between 1 January 2023 and 31 December 2024. Among the 195 submissions accepted by the RAC were the first New Zealand records of Horsfield's bronze-cuckoo (*Chrysococcyx basalis*), MacGillivray's prion (*Pachyptila macgillivrayi*), and the Asian subspecies of gull-billed tern (*Gelochelidon nilotica affinis*). We also report the second accepted records of stilt sandpiper (*Calidris himantopus*), Bulwer's petrel (*Bulweria bulwerii*), and dusky woodswallow (*Artamus personatus*), the third accepted sighting of northern pintail (*Anas acuta*), and the second and third accepted records of streaked shearwater (*Calonectris leucomelas*). Other notable records included the first records of Kermadec petrel (*Pterodroma neglecta*) and brown booby (*Sula leucogaster*) at Rēkohu/Wharekauri/Chatham Islands, plumed whistling duck (*Dendrocygna eytoni*) at the Snares Islands/Tini Heke, Canada goose (*Branta canadensis*) and black shag (*Phalacrocorax carbo*) at Antipodes Island/Moutere Mahue, and fork-tailed swift (*Apus pacificus*) and tree martin (*Petrochelidon nigricans*) at the Auckland Islands/Motu Maha. We also clarify the dates of occurrence of the first vagrant lesser frigatebird (*Fregata ariel*), Australian pelican (*Pelecanus conspicillatus*), and black-faced cuckoo-shrike (*Coracina novaehollandiae*), all recorded from New Zealand before 1900.

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Keywords: Horsfield's bronze-cuckoo, MacGillivray's prion, gull-billed tern, first record, New Zealand bird, vagrant

INTRODUCTION

Birds New Zealand (Birds NZ) requires sightings of vagrant or extra-limital bird species, or species otherwise considered to be extinct, to be verified by the Records Appraisal Committee (RAC) before the records can be presented as accepted New Zealand records in the periodicals *Notornis*, *Birds New Zealand*, and *Ornithological Society of New Zealand Occasional Publications*, or in other books and websites published by Birds NZ.

Here, we report RAC decisions made on Unusual Bird Reports (UBRs) received between 1 January 2023 and 31 December 2024, following on from the last report of the RAC (Miskelly *et al.* 2023).

Results of RAC decisions are posted on the Unusual Bird Report website (http://rare.birds.org.nz/) every 2 months. The website provides a means for observers to determine whether a UBR has already been submitted for any vagrant bird seen or reported, and (within 2–4 months) to see the RAC decision on the UBR. This biennial report provides more detail about sightings than what is presented on the website, including providing context for the significance of each sighting.

Each UBR received is given a number whereby the first four digits represent the year the record was received and the last three digits the chronological sequence of receipt within that year. These reference numbers are given for each record below and match those on the Unusual Bird Report website. Nomenclature and taxonomic sequence follow Checklist Committee (2024). Where images of birds reported here have been published on New Zealand Birds Online (NZBO, www.nzbirdsonline.org.nz, viewed 8 Aug 2025) this is mentioned in the text.

The RAC convenor maintains a database of verified sightings of vagrant birds in New Zealand.

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The RAC convenor maintains a database of verified sightings of vagrant birds in New Zealand. Information from this database is presented below (sourced as "CMM, *unpubl. data*") if it conflicts with or augments information from published sources.

DECISIONS ON SUBMITTED SIGHTINGS

Accepted records of vagrant and rare migrant species to New Zealand

Plumed whistling duck (*Dendrocygna eytoni*)
Three on North East Island, Snares Islands/Tini Heke, between 25 Mar & 7 Apr 2023 (Paul & David Sagar, and David Thompson; UBR 2023/062) were the first record from the Snares Islands or any of the subantarctic islands. Ten at Lake Killarney, Tākaka, on 19 Dec 2024 (Wendy Hare and John Longden; UBR 2024/110). There are 18 previous accepted records of singles or flocks of up to 14 birds (Miskelly *et al*. 2017, 2023).

Chestnut-breasted shelduck (*Tadorna tadornoides*)
A male near Meremere, Waikato, on 2 Dec 2023 (Colin & Gordon Miskelly; UBR 2024/058); a male shot near Martinborough, Wairarapa, on 15 May 2024 (Wellington Fish and Game; UBR 2024/045). There are 42 previous accepted records in New Zealand (Heather 1987; Miskelly *et al.* 2023).

Chestnut teal (*Anas castanea*)
One at Ashburton/Hakatere River mouth, Canterbury, on 21 & 22 Jun 2023 (Andrew Crossland and Tom Broughton; UBR 2023/079). There are 20 previous accepted records from New Zealand (Miskelly *et al.* 2023).

Northern pintail (*Anas acuta*)
A female at Tip Lagoon, Invercargill, on 9 Sep 2023 (Oscar Thomas; UBR 2024/072) was the third record from New Zealand. This was the same location, and was likely the same individual as the second record (October 2021; Miskelly *et al.* 2023).

Northern shoveler (*Spatula clypeata*)
One at Pegasus Wetland, Canterbury, on 30 Mar 2023 (Christian Cosgrove and 13 other observers; UBR 2023/085); one Lake Elterwater, Marlborough, on 26 Apr 2024 (Dave Howes, Malcolm & Michael Boswell; UBR 2024/039); one at Bromley oxidation ponds, Christchurch, on 10 Dec 2024 (A. Xiong; UBR 2024/106).

There was an unprecedented influx of northern shovelers in 2017–18, with at least five different birds present in June 2018 (Miskelly *et al*. 2019). They continued to be reported frequently during 2019–2022 (Miskelly *et al*. 2021, 2023).

Australian white-eyed duck (*Aythya australis*)
A mounted male specimen in Auckland Museum (LB3969) collected at Lake Waikare, Waikato, by H. Rowland in mid-June 1908 (date from *Waikato Argus*, Volume XXIV, Issue 3812, 19 Jun 1908, p.2, reported by George Watola; UBR 2023/068) may have been one of the last survivors of the 1867–1895 colonisation attempt (Oliver 1955). One at Wakapuaka oxidation ponds, Nelson, on 24 Apr 2023 (Warwick Allen, Aleisha & Heather Fisher; UBR 2023/058). There are ten previous records accepted since 1973 (Miskelly *et al.* 2017).

Hoary-headed grebe (*Poliocephalus poliocephalus*)
One in Waihopai Valley, Marlborough, on 30 Jun 2024 (Patrick Crowe and nine other observers; UBR 2024/085) may have come from Lake Elterwater about 45 km away, where at least two pairs plus juveniles were reported between 2014 and 2018 (Miskelly *et al.* 2019), with eBird records indicating a population still present in 2024.

Pallid cuckoo (*Cacomantis pallidus*)
One at Ringa Ringa, Rakiura/Stewart Island, on 19 Oct 2022 (Matt Jones and Phil Burns; UBR 2023/026) was the first from Stewart Island and the eighth from New Zealand (Miskelly *et al*. 2021).

Horsfield's bronze-cuckoo (*Chrysococcyx basalis*)
A juvenile found dead on Muriwai Beach, West Auckland, on 16 Mar 2024 (UBR 2024/077; Auckland Museum specimen LB16349) was the first record from New Zealand (Galbraith & Gill 2025).

White-throated needletail (*Hirundapus caudacutus*)
One at Mount Eden/Te Tātua-a-Riukiuta, Auckland, on 7 Jan 1912 (Ivan G.L. Blyth, reported by George Watola; UBR 2023/089) becomes the second known record from New Zealand, following one shot at Manaia, Taranaki, in March 1888 (Kirk 1889). One at Motupōhue/Bluff Hill, Southland, on 27 Dec 2022 (Sean & Pip Jacques; UBR 2023/003). White-throated needletails are frequent vagrants to New Zealand (Checklist Committee 2022).

Fork-tailed swift (*Apus pacificus*)
One at Enderby Island, Auckland Islands/Motu Maha, on 27 Dec 2022 (Dave Howes and Matt Jones; UBR 2023/004) was the first record from the Auckland Islands. Two at Tiritiri Matangi Island on 7 Jan 2023 (Steve & Anna Sutcliffe, and Morag Fordham; 2023/008), and three at **Ō**pihi River near Pleasant Point, South Canterbury, on 19 Aug 2023 (Don Geddes; 2023/101). One at Antipodes Island/Moutere Mahue on 6 Dec 2024 (Thomas Mattern; UBR 2024/113) was the second record from Antipodes Island (Medway 2003). There were 16 previous accepted New Zealand records (Miskelly *et al*. 2021).

Black-tailed native-hen (*Tribonyx ventralis*)
One at Murchison on 8 Feb 2023 (Oscar Thomas, Ela Hunt, and Noah Fenwick; UBR 2023/030, images on NZBO); one at Cascade Creek Campsite, Eglinton Valley, Fiordland, on

7 & 15 Nov 2024 (Richard Schofield and Michael Burton-Smith; UBR 2024/103a & b). There were six previous accepted New Zealand records (Miskelly *et al*. 2013).

Grey plover (*Pluvialis squatarola*)
One at Manukapua/Big Sand Island, Kaipara Harbour, on 17 Aug 2024 (Oscar Thomas and Ela Hunt; UBR 2024/075). Single grey plovers were reported annually from 2001 to 2005; this is the fifth record since then (Miskelly *et al.* 2021).

Semipalmated plover (*Charadrius semipalmatus*)
One at Manukapua/Big Sand Island, Kaipara Harbour, on 22 & 27 June and 12 Jul 2024 (Phil Hammond, Tony Crocker, and four other observers; UBR 2024/054) was the third accepted record from New Zealand (Miskelly *et al*. 2013).

Greater sand plover (*Anarhynchus leschenaultii*)
Two at Awarua Bay, Southland, on 20 Nov 2021 (Oscar Thomas and seven other observers; 2024/073); one at Te Waihora/Lake Ellesmere, Canterbury, 8 Jan 2023 (Fraser Gurney and Jesse Rubenstein; UBR 2023/134), one at Kaitorete Spit, Canterbury, on 6 May 2023 (Ben Ackerley; UBR 2023/103). Considered an annual visitor to New Zealand before 2010, these are the seventh to ninth records accepted since then (Checklist Committee 2010; Miskelly *et al.* 2023).

Whimbrel (*Numenius phaeopus*)
One at Te Awapatiki, Rēkohu/Wharekauri/Chatham Island, on 29 Dec 2022 (Mike Bell; UBR 2023/018) was the seventh record from the Chatham Islands.

Little whimbrel (*Numenius minutus*)
Two at Whatipu, West Auckland, on 31 Jan 2015 (Russell Cannings; UBR 2024/076); one at New River Estuary, Invercargill, on 11 & 19 February and 5 Mar 2023 (Sean Jacques, Paul Jacques, Joe Bliss, Anna Harris, and Pete McClelland; UBR 2023/054). Considered an uncommon visitor to New Zealand (Checklist Committee 2022); there have been eight accepted records since 2010 (Miskelly *et al.* 2023).

Black-tailed godwit (*Limosa limosa melanuroides*)
One at Pūkorokoro/Miranda, Firth of Thames, on 6 Feb 2023 (Oscar Thomas and Ela Hunt; UBR 2023/045). Black-tailed godwits are uncommon but probably annual visitors to New Zealand (Checklist Committee 2022).

Hudsonian godwit (*Limosa haemastica*)
One at Kaikorai Lagoon, Otago, on 4 Mar 2023 (Peter Fuller; UBR 2023/028); one at Manawatu River estuary on 3 Oct 2023 (Jim Norris, Alan Tennyson, and two other observers; UBR 2023/107). Hudsonian godwits are uncommon but probably annual visitors to New Zealand (Checklist Committee 2022).

Great knot (*Calidris tenuirostris*)
One at Manukapua/Big Sand Island, Kaipara Harbour, on 3 Oct 2023 (Tony Crocker, Dave Howes, and John Kyngdon; UBR 2023/127). There are 23 previous accepted records from New Zealand (Miskelly *et al*. 2023).

Stilt sandpiper (*Calidris himantopus*)
One at Waituna Lagoon, Southland, on 14 Sep 2024 (Sean Jacques; UBR 2024/080) was the second record from New Zealand (Medway 2001).

Long-toed stint (*Calidris subminuta*)
One at Waituna Lagoon, Southland, on 14 Jan 2024 (Sean Jacques; UBR 2024/024) was the fourth record from New Zealand and the first away from Te Waihora/Lake Ellesmere (Checklist Committee 2022; Miskelly *et al*. 2023).

Sanderling (*Calidris alba*)
One at Ashley River/Rakahuri estuary, Canterbury, on 18 Feb 2023 (Don Geddes; UBR 2023/043). One or two sanderlings reach New Zealand most years (Miskelly *et al.* 2019, 2021).

Pectoral sandpiper (*Calidris melanotos*)
Three on the northern shore of Te Whanga Lagoon, Rēkohu/Wharekauri/Chatham Island, on 12 Mar 2023 (Tom Hitchon; UBR 2023/052) was the fifth record from the Chatham Islands (Miskelly *et al*. 2015).

Terek sandpiper (*Xenus cinereus*)
One at Te Waihora/Lake Ellesmere on 25 Oct 2023 (Warwick Allen; UBR 2023/111); one at Motueka sandspit on 12 Feb 2024 (Craig Martin; UBR 2024/017); one at Ashley River/Rakahuri estuary on 27 Oct 2024 (Nicholas Allen; UBR 2024/092) follow the three reports during 2021-22 (Miskelly *et al*. 2023). No Terek sandpipers were reported between 2015 and 2020 (Miskelly *et al*. 2023).

Wandering tattler (*Tringa incana*)
Two at Kaikōura Peninsula on 17 Aug 1988 (George & Julia Watola; UBR 2023/095); one at Tapotupotu Beach, near Cape Reinga, on 11 Oct 2023 (Darryl Jeffries and Clara Ampe; UBR 2023/113); one at Proctor's Beach, Whangārei Heads, on 3 Nov 2023 (Cathy Mitchell; UBR 2023/114). Wandering tattlers are uncommon but probably annual visitors to the New Zealand mainland (Checklist Committee 2022). Two at Cape Pattison, Rēkohu/Wharekauri/Chatham Island, on 4 Jan 2023 (Mike Bell; UBR 2023/017) were the tenth accepted record from the Chatham Islands (Miskelly *et al.* 2023).

South Polar skua (*Stercorarius maccormicki*)
Single birds east of Poor Knights Islands on 1 Dec 2023, and 13 & 27 October, 11 November, and 1 Dec 2024 (Scott Brooks and 35 other observers; UBRs 2024/034, 2024/086, 2024/100, 2024/101, & 2024/108). South Polar skuas are scarce but likely annual migrants to New Zealand, with 25 previous accepted records (Miskelly *et al*. 2023).

Pomarine skua (*Stercorarius pomarinus*)
One south of Rangihaute/Rangiauria/Pitt Island, Chatham Islands, on 3 Feb 2023 (Johannes Fischer; UBR 2023/086) was the second accepted record from the Chatham Islands (Miskelly *et al.* 2006).

Long-tailed skua (*Stercorarius longicaudus*)
One dead on Te Horo beach, Horowhenua, on 13 May 2020 (Alan Tennyson; UBR 2024/079); singles east of Poor Knights Islands on 13 Oct 2024 & 4 Nov 2024 (Scott Brooks and 11 other observers; UBRs 2024/087 & 2024/094). Long-tailed skuas are scarce annual migrants to New Zealand (Miskelly *et al.* 2019).

White tern (*Gygis alba*)
One at sea west of Cape Reinga on 11 Dec 2022 (Jordan Roderick and six other observers; UBR 2023/051). There are about 17 previous New Zealand records away from the Kermadec Islands/Rangitāhua (Miskelly *et al.* 2021).

Little tern (*Sternula albifrons*)
One at Brooklands Lagoon, Christchurch, on 2 Apr 2019 and 8 Mar 2023 (Andrew Crossland [both records], Antony Shadbolt, and Hannah Murdoch [2023]; UBRs 2023/031 & 2023/037); one at outlet of Lake Forsyth/Wairewa, Banks Peninsula, on 22 Jul 2019 and 13 Feb 2023 (Andrew Crossland; UBRs 2023/032 & 2023/039); one at the tip of Kaitorete Spit, Te Waihora/Lake Ellesmere, on 23 Jan 2020 & 2 Apr 2023 (Andrew & Xavier Crossland, and Philip Crutchley respectively; UBRs 2023/036 & 2023/050), with two there on 12 Mar 2023 (Philip Crutchley; UBR 2023/041); one at Ashburton/Hakatere River estuary

on 18 Dec 2021 (Andrew Crossland and Frances Schmechel; UBR 2023/038); six at New River estuary, Invercargill, between 13 May 2022 and 17 Jun 2023 (Sean Jacques and four other observers; UBR 2023/090); one at Birdings Flat Beach, Banks Peninsula, on 6 & 8 Jan 2023 (David Newell, and Tom Broughton and Laura Smith respectively; UBRs 2023/005a & b); one at Te Waewae Lagoon, western Southland, on 12 Apr 2023 (Sean Jacques; UBR 2023/073). Little terns are annual migrants to northern New Zealand, with a few previous records as far south as Invercargill and Rakiura/Stewart Island (Higgins & Davies 1996). Following this spate of South Island records, little terns are no longer a reportable species for either of the two main islands.

Figure 1. Gull-billed tern of the Asian subspecies (*Gelochelidon nilotica affinis*) at Big Sand Island, Kaipara Harbour, January 2023 (image by Dave Howes; UBR 2023-007).

Gull-billed tern (*Gelochelidon nilotica*)
A gull-billed tern of the Asian subspecies (*G. n. affinis*) at Manukapua/Big Sand Island, Kaipara Harbour, on 22 Jan 2023 (Dave Howes and Aaron Skelton; UBR 2023/007, Fig. 1) was the first New Zealand record of this subspecies. All remaining New Zealand records since 1955 are considered to be of the Australian subspecies (*G. n. macrotarsa*), including one at Kaikokopu Stream mouth, Himatangi Beach, Manawatu, on 29 Apr 2023 (Ian Armitage; UBR 2023/060); one at Whanganui River estuary on 1 Jun 2023 (Dallas Bishop and Geoff de Lisle; UBR 2023/070); one at Pūkorokoro/Miranda, Firth of Thames, on 15 Jun 2023 (Tansy Bliss; UBR 2023/104); one at Piako wader roost, Firth of Thames, on 27 Aug 2023 (Tansy Bliss; UBR 2023/105), with three there on 2 Sep 2023 (Russell Cannings; UBR 2023/105a); six at Waiuku sandspit, southern Manukau Harbour, on 16 Nov 2023 (Brian Crum; UBR 2023/119); one at Pouto Point, north Kaipara head, on 22 Nov 2023 (Gary & Robyn Wilson; UBR 2023/120); three adults including a breeding pair at Bell Island shellbank, Waimea Inlet, Tasman, on 10 Oct 2024 (David Melville; UBR 2024/081). This last pair laid two clutches, raising two fledglings on the second attempt, which was the second successful breeding of gull-billed terns in New Zealand (Jacques *et al.* 2023; Melville *et al*. 2025).

Whiskered tern (*Chlidonias hybridus*)
One at Waituna Lagoon, Southland, on 14 Mar 2024 (Sean Jacques and Hayley Lister; UBR 2024/049); one at Pūkorokoro/Miranda, Firth of Thames, on 22 Apr 2024 (Dave Howes, Malcolm and Michael Boswell; UBR 2024/040). There had been 17 previous accepted records of whiskered terns in New Zealand (Miskelly *et al.* 2023).

Arctic tern (*Sterna paradisaea*)
One at Stirling Point, Bluff, on 18 Dec 2021 (Johannes Fischer, Igor Debski, and Harry Boorman; UBR 2023/075), with another at Waipapa Point, Southland, on the same date (Johannes Fischer, Jason Preble, and Kris Kokame; UBR 2023/076); one at Kaiaua, Firth of Thames, on 19 Feb 2023 (Russell Cannings; UBR 2023/053); one at Walker Island, Kaipara Harbour, on 9 Feb 2024 (Bradley Shields, Mathieu Poot, and Scott Brooks; UBR 2024/020); one at Ashley River/Rakahuri estuary, Canterbury, on 4 Apr 2024 (Adam Colley; UBR 2024/056). Arctic terns are presumed to be annual visitors to New Zealand (Checklist Committee 2022).

Common tern (*Sterna hirundo*)
One at Waikanae River mouth on 1 Jan 2023 (Alan, David and Sam Tennyson and Bernd Huss; UBR 2023/001), with another there on 14 Jan 2024 (Alan Tennyson; UBR 2024/008); one at Table Cape, Mahia Peninsula, on 17 Apr 2023 (Russell Cannings; UBR 2023/099); one at Whakatiwai, Firth of Thames, on 27 May 2023 (Tony Habraken; UBR 2023/093); one at Hukatere, Ninety Mile Beach, on 4 Nov 2023 (Colin & Gordon Miskelly; 2024/059); one at Argyle Beach, Bluff, on 8 Jan 2024 (Kit Hustler; UBR 2024/023); one at Manawatu estuary on 10 Jan 2024 (Graham Barwell and Rebecca Albury; UBR 2024/004), with another there on 10 Feb 2024 (Neill Haggarty; UBR 2024/018); one at Ashley River/Rakahuri estuary, Canterbury, on 13 Jan 2024 (Christian Cosgrove; UBR 2024/006), with another there on 4 Apr 2024 (Adam & Jack Colley, and Ben Ackerley; UBR 2024/057); four different birds on the Kapiti Coast on 21 & 22 Jan 2024 (Alan Tennyson, Johannes Fischer, and Igor Debski; UBR 2024/027); one at Plimmerton, Wellington, on 16 Feb 2024 (Alan & Sam Tennyson; UBR 2024/022); one at Thames waterfront on 3 Nov 2024 (Tony Habraken; UBR 2024/095); one at Saltwater Creek estuary, Waikuku, Canterbury, on 9 Nov 2024 (Ben Ackerley; UBR 2024/102).

There are about 80 accepted records of common terns from New Zealand, with nearly half of these being from the Manawatu estuary/Foxton Beach or from Waikanae, 49 km to the south (Miskelly et al. 2023). Common terns are no longer a reportable species on the North or South Islands.

Crested tern (*Thalasseus bergii*)
One at Maukatia Bay, Muriwai, West Auckland, on 24 Oct 2024 (Tony Habraken; UBR 2024/091) was the 20th accepted record (Miskelly *et al.* 2021 & 2023).

King penguin (*Aptenodytes patagonicus*)
One at Oreti Beach, Invercargill, on 12 Jul 2024 (Pat Hoffman and six other observers; UBR 2024/053) was the eighth record of a king penguin from the South Island (Miskelly *et al.* 2023).

Adelie penguin (*Pygoscelis adeliae*)
Adults at Monkey Island, Te Waewae Bay, Southland, on 4 Jan 2024 (Bill McMurray and Pippa Brown; UBR 2024/007), St Clair Beach, Dunedin, on 15 & 16 Jan 2024 (Jim Watts and four other observers; UBR 2024/009) and at Petone Beach, Wellington on 12 Oct 2024 (Joss Debreceny via Michael Szabo; UBR 2024/082) were the sixth to eighth records of Adelie penguins from New Zealand (Miskelly *et al.* 2022 & 2023).

Royal penguin (*Eudyptes chrysolophus schlegeli*)
One at Flower Pot, Rangihaute/Rangiauria/Pitt Island, Chatham Islands, on 15 Feb 2023 (Celine Gregory-Hunt via Mike Bell; UBR 2023/023) was the fifth record from the Chatham Islands (Miskelly *et al.* 2021).

Atlantic yellow-nosed albatross (*Thalassarche chlororhynchus*)
One at Motuhara/The Forty Fours, Chatham Islands, on 8 Dec 2022 (Mike & Dave Bell; UBR 2023/019) was the fourth record from the Chatham Islands and the sixth from New Zealand (Miskelly *et al.* 2006 & 2021).

Indian Ocean yellow-nosed albatross (*Thalassarche carteri*)
One off Cape Foulwind, Westport, on 16 Jan 2024 (Javier Cotin; UBR 2024/011); one east of the Poor Knights Islands on 22 Sep 2024 (Aaron Skelton and eight other observers, via Scott Brooks; UBR 2024/078). This species was an annual visitor to northern New Zealand until the 1980s; since then, it has been reported only two or three times a decade (Miskelly *et al*. 2019 & 2023).

Leach's storm petrel (*Hydrobates leucorhous*)
One at Taiaroa Head, Otago, on 23 Mar 2023 (recorded on the "Royal Cam" albatross trail camera, reported via Johannes Fischer; UBR 2023/117) was the first live record from the New Zealand mainland (Checklist Committee 2022).

Juan Fernandez petrel (*Pterodroma externa*)
One off Pukerua Bay, north of Wellington, on 3 Feb 2024 (Johannes Fischer and Igor Debski; UBR 2024/021) was the fifth record on or near the main islands of New Zealand, and was at a similar time of year to one seen north-west of Mana Island (i.e. near Pukerua Bay) in March 2019 (Miskelly *et al.* 2021).

Gould's petrel (*Pterodroma leucoptera*)
Nine 570–650 km north-east of North Cape on 8 Nov 2023, seven 290–350 km north-west of Raoul Island, Kermadec Islands, on 8 Nov 2023, and two 290 km east of North Cape (all Oscar Thomas and Ela Hunt; UBRs 2023/121, 2023/122 & 2023/123) confirm this species as regularly present in seas north of New Zealand between December and April (Miskelly *et al.* 2023), although they have also occurred as beach-wrecks in May, June, and November (Powlesland 1987).

Bulwer's petrel (*Bulweria bulwerii*)
One found live on New Brighton Beach, Christchurch, on 22 Jan 2014 subsequently died, and is now specimen 2020.23.1 in Canterbury Museum (Paul Scofield via George Watola; UBR 2023/088). This was the second accepted New Zealand record, following one that washed ashore on Te Horo Beach, north of Wellington, in January 1998 (Checklist Committee 2022).

Blue petrel (*Halobaena caerulea*)
One at Papanui Canyon, off Otago Peninsula, on 11 Jul 2024 (Oscar Thomas and six other observers; UBR 2024/051) was the third accepted at-sea sighting of this species from New Zealand north of the subantarctic zone (Miskelly *et al.* 2019).

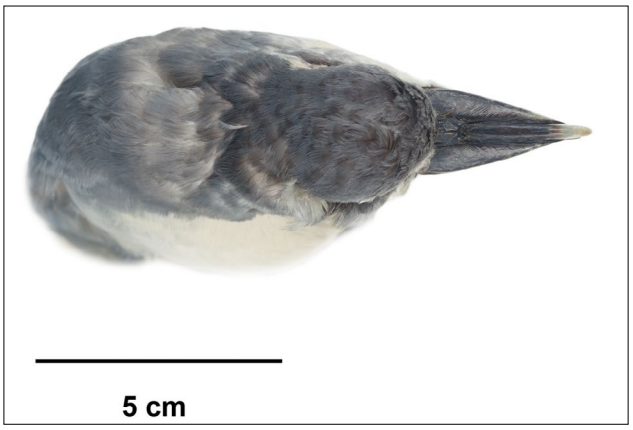

Figure 2. Dorsal view of head and bill of the MacGillivray's prion (*Pachyptila macgillivrayi*) found beach-wrecked on Ōtaki Beach, Horowhenua, in July 1954 (Museum of New Zealand Te Papa Tongarewa specimen OR.021886; image by Jean Claude Stahl, Te Papa).

MacGillivray's prion (*Pachyptila macgillivrayi*)
One found beach-wrecked on Ōtaki Beach, Horowhenua, by Peter Bull on 4 Jul 1954 was acquired by the National Museum of New Zealand (now Museum of New Zealand Te Papa Tongarewa) in 1979 via the Falla Collection, and was registered as a broad-billed prion (*Pachyptila vittata*; specimen OR.021886, Fig. 2). It was identified as a MacGillivray's prion using genetic methods in 2024, with mitochondrial DNA and bill measurements indicating that it came from Gough Island in the South Atlantic Ocean, rather than the closer St Paul Island population in the southern Indian Ocean (Miskelly *et al.* 2025; UBR 2024/107). First accepted New Zealand record.

Thin-billed prion (*Pachyptila belcheri*)
One south of Antipodes Island/Moutere Mahue on 13 Dec 2022 (Mike Sylvia and seven other observers; UBR 2023/025); two at Papanui Canyon, off Otago Peninsula, on 11 Jul 2024 (Oscar Thomas and six other observers; UBR 2024/052), with one there on 11 Aug 2024 (Oscar Thomas and five other observers; UBR 2024/068). Thin-billed prions are regularly found dead on New Zealand beaches in winter (Powlesland 1989). However, the Records Appraisal Committee has accepted only four previous reports of birds seen at sea (Miskelly *et al*. 2023).

Figure 3. Streaked shearwater (*Calonectris leucomelas*) east of the Poor Knights Islands, November 2023 (image by Oscar Thomas; UBR 2023-112).

Streaked shearwater (*Calonectris leucomelas*)
One east of the Poor Knights Islands on 1 Nov 2023 (Oscar Thomas, Scott Brooks, and nine other observers; Fig. 3 plus images on NZBO, UBR 2023/112) was the second record, and first live record, from New Zealand (Scofield *et al*. 2011). One long dead at Moa Point, Wellington, on 27 Oct 2024 (Te Papa specimen OR.031459; Alan Tennyson, UBR 2024/111) becomes the third accepted record.

Great shearwater (*Ardenna gravis*)
One off Taiaroa Head, Otago, on 23 Mar 2023 (Oscar Thomas; UBR 2023/035) was the 11th accepted record from New Zealand (Miskelly *et al*. 2021 & 2023).

Lesser frigatebird (*Fregata ariel*)
One found at Farewell Spit on 15 Apr 1891 is the first record from New Zealand (UBR 2023/074; date and species identification clarified by Watola 2025). This specimen was originally identified by Buller (1892) as a great frigatebird (*F. minor*), and there has also been confusion over whether

the bird was found in 1891 or 1901 (Buller 1892 & 1906). The specimen is held by Carnegie Museum (CMNH 24551; Bartle & Tennyson 2009). One at Mercury Cove, Great Mercury Island, on 1 Mar 2024 (Sandra & Chris Constance; UBR 2024/026). There are at least 42 previous records (Miskelly *et al.* 2023).

Brown booby (*Sula leucogaster*)
One dead on Motuhara/The Forty Fours, Chatham Islands, on 10 Dec 2022 (Mike & Dave Bell; UBR 2023/016) was the first record from the Chatham Islands.

Australian pelican (*Pelecanus conspicillatus*)
One shot a mile above Hiruhārama/Jerusalem, Whanganui River, in June 1889 (Samuel Drew via George Watola; UBR 2023/084) was the first record of a vagrant pelican following European contact. This record has previously been reported as 1890 (Buller 1893; Checklist Committee 2022); an article in *The Wanganui Chronicle* on 10 Jul 1889 (Vol. XXXII, Issue 11431, p.2) clarifies that it was shot in June 1889 or earlier in that year (George Watola, UBR 2023/084).

Pacific heron (*Ardea pacifica*)
One at Waitangiroto Nature Reserve, Whataroa, West Coast, on 8 Jan 2024 (Dion Arnold; UBR 2024/005); there are 12 previous accepted records (Miskelly *et al*. 2015).

Black-faced cuckoo-shrike (*Coracina novaehollandiae*)
One shot at Motueka in or before August 1864 (W. Giblin via George Watola; UBR 2023/069) was the first record from New Zealand. This specimen has previously been reported as having been collected *c*. 1869 (Hutton 1871; Checklist Committee 2022); an article in the *Timaru Herald* on 13 Aug 1864 (Vol. I, Issue 10, p. 6) clarifies that it was shot in August 1864 or earlier that year (George Watola, UBR 2023/069).

Dusky woodswallow (*Artamus cyanopterus*)
One at Oban, Rakiura/Stewart Island, 8–10 Sep 2024 (Adrian Munro and six other observers, image on NZBO; UBR 2024/074) was within a kilometre of the site of the only other accepted record, of a bird seen on 27 Sep 2014 (Kakishima & Morimoto 2015).

Fairy martin (*Petrochelidon ariel*)
One at Whenua Hou/Codfish Island on 15 Oct 2023 (Johannes Fischer; UBR 2023/109). There are 13 previous records from New Zealand (Miskelly *et al.* 2011).

Tree martin (*Petrochelidon nigricans*)
One at Aniseed Valley, Tasman, on 24 Oct 2022 (Paul Bennett; UBR 2023/132). There are more than 50 accepted records from the New Zealand mainland (Miskelly *et al.* 2021). One at Enderby Island, Auckland Islands/Motu Maha, on 5 Feb 2023 (Niall Mugan and Kate Sutherland; UBR 2023/042) was the first record from the Auckland Islands.

Accepted extra-limital records of New Zealand breeding species

Canada goose (*Branta canadensis*)
One at Antipodes Island/Moutere Mahue on 12 Nov 2024 (Jeff White, Thomas Mattern, and Myrene Otis; UBR 2024/099) was the first record from Antipodes Island. Elsewhere in the New Zealand subantarctic, Canada geese have occurred at the Snares Islands/Tini Heke (Miskelly *et al.* 2001, 2021), Auckland Islands/Motu Maha (Miskelly *et al.* 2020), and Campbell Island/Motu Ihupuku (in late 2011, Kyle Morrison *pers. comm*. to CMM).

Grey teal (*Anas gracilis*)
One at North East Island, Snares Islands/Tini Heke, on 7 Apr 2023 (Paul & David Sagar; UBR 2023/063) was the second record from the Snares Islands (Miskelly *et al.* 2001). Further south, grey teal have reached the Auckland Islands/Motu Maha (Miskelly *et al.* 2020), and Campbell Island/Motu Ihupuku (two in October 2012, Kyle Morrison *pers. comm*. to CMM).

New Zealand dabchick (*Poliocephalus rufopectus*)
One at Pegasus wetlands, North Canterbury, on 16 Apr 2023 (Christian Cosgrove, Bradley Shields, Bev Alexander, and Warwick Allen; UBR 2023/055); one at Lake Forsyth/Wairewa, Banks Peninsula, on 22 May and 31 Jul 2023, with two there on 27 Jun 2023 (Andrew Crossland; UBRs 2023/066 & 2023/097); one at St Anne's Lagoon, Cheviot, on 1 May 2023 (Dallas Bishop and Geoff de Lisle; UBR 2023/072); one 18 km west of Ashburton on 18 Jun 2023 (Nick Allen and Don Geddes; UBR 2023/078).

New Zealand dabchicks are widespread in the North Island and have a small, recently established population in the Nelson and Marlborough regions, and regularly occur in Canterbury (Miskelly *et al.* 2019, 2021, 2023). They are no longer reportable on the east coast of the South Island north of the Waitaki River.

Australasian little grebe (*Tachybaptus novaehollandiae*)
One at wastewater treatment ponds, Wakapuaka, Nelson, on 27 Mar 2023 (Peter Field; UBR 2023/047); one at Pharazyn Reserve, Waikanae, on 6 Apr 2023 and 20 Oct 2024 (Diane Parker and Duncan Watson; UBRs 2023/046 & 2024/089); one at Barrytown, West Coast, on 26 Apr & 28 Jun 2023 (Stuart Laurenson and Bradley Shields; UBRs 2023/059 & 2023/092); one at Franz Josef wastewater treatment ponds on 12 Jul 2023 (Bradley Shields and Chad Cottle; UBR 2023/091); one at Styx Mill Reserve, Christchurch, on 25 Nov 2023 (Warwick Allen; UBR 2023/126); three at Lake Murray, Tekapo, on 9, 12 & 13 Jan 2024 (Rohan Clarke, Anders Wiig Nielson, and Birgitte Mortenen; UBR 2024/010a & b); two at Bankhouse Estate, Waihopai Valley, Marlborough, on 27 Jan & 30 Jun 2024 (Patrick Crowe and 13 other observers; UBRs 2024/014 & 2024/084).

This rare breeding species is resident in Northland and North Auckland (Beauchamp 2019). There were only four South Island records between 2008 and 2023 (Miskelly *et al.* 2019, 2021, 2023).

Spotted dove (*Streptopelia chinensis*)
At least 50 around Charing Cross, Canterbury, on 26 Mar 2023 (Andrew Crossland; UBR 2023/040); one at Norwood, mid-Canterbury, on 6 May 2023 (Andrew Crossland; UBR 2023/061). The Charing Cross population is recently established and is the only known South Island population (Miskelly *et al.* 2023). Spotted doves are no longer reportable in the portion of northern Canterbury between Waimakariri and Rakaia Rivers.

Australian coot (*Fulica atra*)
Four at North East Island, Snares Islands/Tini Heke, between 25 March and 9 Apr 2023 (Paul & David Sagar and David Thompson; 2023/064) were the second record from the Snares Islands (Miskelly *et al.* 2015). One captured on a trail camera at Teal Lake, Enderby Island, on 11 May 2023 (Bronwyn Jeynes and Sean Jacques; UBR 2024/065) was the second record from the Auckland Islands/Motu Maha (Miskelly *et al.* 2020).

Marsh crake (*Zapornia pusilla*)
One captured alive on Golden Bay Track, Rakiura/Stewart Island, on 6 May 2024 (Daniel Cocker and Guy McDonald; UBR 2024/038). Oliver (1955) included Stewart Island

within the distribution range of marsh crake without providing further detail. There are no known records south of Stewart Island.

Sooty tern (*Onychoprion fuscata*)
One dead at Lake Rotoehu, Bay of Plenty, on 13 Jan 2023 (Steven Crosbie; UBR 2023/011); at least 17 at Ngunguru, Northland, on 13 Feb 2023 (Scott Brooks and family; UBR 2023/015); one at Walker Island, Raungaunu Harbour, Far North, on 30 Nov and 14 Dec 2023 (Mathieu Poot and George Watola; UBRs 2023/130 & 2024/012). Within the New Zealand region, sooty terns breed only on the Kermadec Islands, with at least 18 previous records from elsewhere in the region (Veitch *et al*. 2004; Miskelly *et al.* 2023).

Antarctic tern (*Sterna vittata*)
One at Aramoana Mole, Otago, on 7 Dec 2023 (Oscar Thomas, Nick Beckwith, Ela Hunt, and Janina Castro; UBR 2023/124) was the first record accepted by the RAC for an Antarctic tern ashore in the South Island.

Eastern rockhopper penguin (*Eudyptes filholi*)
One at Conway Flat, south of Kaikōura, on 1 Feb 2024 (Sabrina Luecht, Jemima Rodden, and Roger Williams; UBR 2024/015) was the fifth accepted South Island record. Most records before 2010 did not differentiate between the three species of rockhopper penguins (Miskelly *et al.* 2023).

Erect-crested penguin (*Eudyptes sclateri*)
One between Flea Bay and Stony Bay, Banks Peninsula, on 3 Feb 2023 (Charles & Jenny Wall, David & Amanda Goodburn; UBR 2023/012); one at Curio Bay, Southland, on 9 Feb 2023 (alongside a Fiordland crested penguin – Franziska Benz; UBR 2023/010); one at Toetoes Bay, Waituna, Southland, 13 & 26 Feb 2023 (Sean Jacques, Trevor Huggins, Joe Bliss, and Pete McClelland; UBR 2023/056); one at South Bay, Kaikōura, on 20 Feb 2023 (Patrick Crowe; UBR 2023/033); one at sea at 45.0°S 179.2°E (between Chatham Islands and Bluff) (Gillian Matthew, Jonas Giese, and eight other observers; UBR 2023/135). Erect-crested penguins breed on the Bounty and Antipodes Islands, with at least one bird reported moulting on the east coast of the South Island and on the Chatham Islands during January–March most years (Miskelly *et al.* 2019, 2023). This species is no longer reportable from the Chatham Islands or eastern South Island.

Fiordland crested penguin (*Eudyptes pachyrhynchus*)
One at Curio Bay, Southland, on 9 Feb 2023 (alongside an erect-crested penguin – Franziska Benz; UBR 2023/010); one at Sumner, Christchurch, on 14 Aug 2023 (Ben Ackerley; UBR 2023/102). Fiordland crested penguins are no longer reportable from the South Island south of Karamea on the west coast and Kaikōura on the east coast.

Snares crested penguin (*Eudyptes robustus*)
One at Ocean Beach, Little Glory, Rakiura/Stewart Island, on 29 Apr 2023 (Brittany Trask; 2023/057) was the first record of this species that the RAC has accepted from Stewart Island, although it has been recorded from Bench Island off the north-east coast (Miskelly *et al.* 2019).

Yellow-eyed penguin (*Megadyptes antipodes*)
One at Kaikōura on 6 Mar & 27 Nov 2023 (Harrison Bowers, Alexandre, Peter & Sandra Kite, Tommy Pedersen, and Maja Pesic Pedersen; UBRs 2023/044 & 2023/133); and one at Wairau diversion mouth, Blenheim, on 23 Apr 2024 (Patrick Crowe and Rowan Hindmarsh-Walls; UBR 2024/043) were north of their usual range (Marchant & Higgins 1990).

Chatham Island albatross (*Thalassarche eremita*)
One east of the Poor Knights Islands on 1 Nov 2023, with two there on 3 Nov 2023, and one on 12 Nov 2023 (Scott Brooks and 23 other observers; UBRs 2023/115, 2023/116 & 2024/032); one at Taiaroa Canyon, off Otago Peninsula, on 22 Jun 2024 (Oscar Thomas and 11 other observers; UBR 2024/048); one at Papanui Canyon, off Otago Peninsula, on 10 Aug 2024 (Oscar Thomas and nine other observers; UBR 2024/069). There are 11 earlier records from New Zealand mainland coastal waters in the RAC database, and at least 10 earlier unreported records (Miskelly *et al.* 2019, 2023). These recent records suggest that the species is regularly present off north-eastern New Zealand during October to December and off Otago in winter. Chatham Island albatross is no longer reportable east of the North and South Islands.

Grey-backed storm petrel (*Garrodia nereis*)
Four east of the Poor Knights Islands on 6 Aug 2023 (Scott Brooks and seven other observers; UBR 2023/096); one off Sinclair Head, Wellington, on 26 Jul 2023 (Oskar Ehrhardt; UBR 2023/100). Grey-backed storm petrel is reportable north of Cook Strait. These are the second and third northern records accepted by the RAC. For earlier northern records, see Gaskin & Baird (2005) and Miskelly (2006).

Black-bellied storm petrel (*Fregetta tropica*)
One east of the Poor Knights Islands on 22 Apr 2024 (Gary Setterfield and two other observers; UBR 2024/031). Black-bellied storm petrel is reportable north of Banks Peninsula. This was the third northern record accepted by the RAC (Miskelly *et al.* 2023).

Kermadec petrel (*Pterodroma neglecta*)
Four collected *c*. 110 km north-east of Poor Knights Islands on 19 Dec 1858 (UBR 2024/050) was the earliest record near the New Zealand mainland, and was 5 years before the species was named (although four years after the type series was collected at the Meyer Islets, Kermadec Islands, in July 1854: Schlegel 1863; Hoek Ostende *et al*. 1997; Miskelly & Braund 2025). One south-east of Hokorereoro/Rangatira/South East Island, Chatham Islands, on 15 Mar 2023 (Matthias Dehling and Hiroyuki Tanoi; UBR 2023/131) was the first accepted record from the Chatham Islands. One east of the Poor Knights Islands on 28 Jan 2024 (Scott Brooks and three other observers; UBR 2024/035) becomes the sixth accepted record from around New Zealand's main islands (Miskelly *et al.* 2023; Miskelly & Braund 2025).

Soft-plumaged petrel (*Pterodroma mollis*)
Singles east of the Poor Knights Islands on 25 May & 19 Jun 2023 (Scott Brooks and 16 other observers; UBRs 2023/081 & 2023/082). Soft-plumaged petrel is reportable north of Cook Strait. There are seven previous northern records accepted by the RAC (Miskelly *et al.* 2023).

Antarctic prion (*Pachyptila desolata*)
Four east of the Poor Knights Islands on 25 May 2023 (Scott Brooks and nine other observers, images on NZBO; UBR 2023/083). Although commonly found dead on New Zealand beaches (Powlesland 1989), live Antarctic prions are reportable north of Banks Peninsula. There are two previous northern records accepted by the RAC (Miskelly *et al.* 2023).

Wedge-tailed shearwater (*Ardenna pacifica*)
Singles near the Poor Knights Islands on 17 Feb & 9 Dec 2024 (Scott Brooks and ten other observers; UBRs 2024/033 & 2024/109). Within the New Zealand region,

wedge-tailed shearwaters breed only on the Kermadec Islands (Veitch *et al*. 2004). There were three previous live records from coastal waters off the mainland accepted by the RAC (Miskelly *et al.* 2023), and several others have been found dead (Checklist Committee 2022).

Red-tailed tropicbird (*Phaethon rubricauda*)
One at Maunganui Bluff, 90 Mile Beach, Far North, on 15 Feb 2023 (Aaron Skelton, Scott Brooks, and Steve Collins; UBR 2023/014). There were 33 previous accepted mainland records (Checklist Committee 2024).

Black shag (*Phalacrocorax carbo*)
Seven at the Snares Islands/Tini Heke on both 27 Nov 2023 and 6 Apr 2024 (Lloyd Esler, Paul Sagar, Graham Parker, and Kalinka Rexer-Huber; UBRs 2023/129 & 2024/036) were the eighth and ninth records from the Snares Islands (CMM, *unpubl. data*). One at Antipodes Island/Moutere Mahue 14–17 Oct 2024 (Jeff White, David Houston, Thomas Mattern, and Myrene Otis; UBR 2024/098) was the first record from Antipodes Island.

Little black shag (*Phalacrocorax sulcirostris*)
Two at the Snares Islands/Tini Heke on 7 Apr 2024 (Paul Sagar and Graham Parker; UBR 2024/037) were the third record from the Snares Islands (Miskelly *et al.* 2015).

Nankeen night heron (*Nycticorax caledonicus*)
A juvenile at Waitati, Dunedin, on 26 Oct 2023 (Monica Graham; UBR 2023/110); a juvenile at Ohakune on 16 May 2024 (Mitchell Black; UBR 2024/042). A few nankeen night herons breed along the Whanganui River; they are rarely reported away from there (Frost 2022; Miskelly *et al.* 2023).

Barn owl (*Tyto alba*)
One Purerua, Northland, on 1 Sep 2023 (Andrew Mentor; UBR 2023/106), one at Home Bay, Bream Head Scenic Reserve, Northland, on 22 Jul 2024 (Tom Grinsted; UBR 2024/055), and one at Ponsonby, Auckland, on 20 Aug 2024 (Natalie Barnes and Courtney Dawson; UBR 2024/060) were all well east or south of the known distribution of New Zealand's only known barn owl population (around Kaitaia; Hyde *et al.* 2020).

Kākā (*Nestor meridionalis*)
One at Oxford, North Canterbury, on 25 Aug 2024 (Christian Cosgrove; UBR 2024/062) and one at Bortons Pond, east of Duntroon, Waitaki River, on 26 Dec 2024 (Liz van den Ende, Arthur & Arron Green; UBR 2024/112) were 40 to 90 km from known kākā breeding populations.

Records not accepted, or held in suspense
Some of the following records may have been correct, but were insufficiently documented to be accepted by the Records Appraisal Committee. At least eight were considered to be misidentifications.

Emu (*Dromaius novaehollandiae*)
Twenty emu north of Lake Huro, Rēkohu/Wharekauri/Chatham Island on 1 Aug 2019 (UBR 2023/034), were readily identifiable. The Checklist Committee intends to consider whether emu should be added to the New Zealand list during the next revision of the checklist.

Plumed whistling duck (*Dendrocygna eytoni*)
One reported at Ashley River/Rakahuri, North Canterbury, on 2 Jan 2024 (UBR 2024/002).

Chestnut teal (*Anas castanea*)
One reported at Playhouse Ponds, Tasman, on 19 Jan 2024 (UBR 2024/013).

Grey teal (*Anas gracilis*) x Australasian shoveler (*Spatula variegata*) hybrid
An unusual duck photographed at Masterton on 15 Jun 2024 (UBR 2024/047) was considered likely to be a hybrid, possibly between a grey teal (*Anas gracilis*) and an Australasian shoveler (*Spatula variegata*) as claimed in the submission.

Northern shoveler (*Spatula clypeata*) x Australasian shoveler (*S. variegata*) hybrid
Male shovelers photographed at Pegasus Wetlands, North Canterbury, on 24 Jul 2022 (UBR 2024/071) and at Tip Lagoon, Invercargill, on 9 Sep 2023 (UBR 2024/070) were both considered to be possible hybrids between these two species.

White-headed pigeon (*Columba leucomela*)
A pigeon photographed at Te Kao, Far North, on 4 Nov 2024 (UBR 2024/096) was considered to be a white-headed pigeon by a majority of RAC members, but did not have the unanimous agreement required for a new species to be added to the New Zealand list.

Fan-tailed cuckoo (*Cacomantis flabelliformis*)
One reported from Belfast, Christchurch, on 3 Nov 2024 (UBR 2024/093) was identified from a photograph as a female Eurasian blackbird (*Turdus merula*).

White-rumped swiftlet (*Aerodramus spodiopygius*)
A swift photographed on Antipodes Island on 6 Dec 2024 (UBR 2024/105) was considered to be a fork-tailed swift (see under that species, renumbered as UBR 2024/113).

Whimbrel (*Numenius phaeopus*)
A call heard at night on Hokorereoro/Rangatira/South East Island, Chatham Islands, on 7 Feb 2023 (UBR 2023/087) was considered a possible record of a whimbrel.

Hudsonian godwit (*Limosa haemastica*)
One reported from Pararekau, Manukau Harbour, on 26 Jan 2020 (UBR 2024/061).

Sharp-tailed sandpiper (*Calidris acuminata*)
A sandpiper photographed at Manukapua/Big Sand Island, Kaipara Harbour, on 21 Nov 2009 (UBR 2024/090) was considered unidentifiable from the images provided.

Red-necked phalarope (*Phalaropus fulicarius*)
One reported from Hot Water Beach, Whitianga, on 1 Jan 2023 (UBR 2023/002) was identified from photographs as a New Zealand dotterel (*Anarhynchus obscurus*).

Grey plover (*Pluvialis squatarola*)
One reported from Puketutu, Manukau Harbour, on 9 Jan 2021 (UBR 2024/064).

Long-tailed skua (*Stercorarius longicaudus*)
Singles reported from Te Haumi River mouth, Far North, on 26 Feb 2024 (UBR 2024/041) and Rothesay Bay, North Shore, Auckland, on 19 Apr 2024 (UBR 2024/030).

Whiskered tern (*Chlidonias hybridus*)
One reported from Walker Island, Kaipara Harbour, on 17 Jun 2023 (UBR 2024/104).

Common tern (*Sterna hirundo*)
One reported from Gulf Harbour, Whangaparāoa, on 26 Feb 2023 (UBR 2023/027). One found dead at Kaika Beach, Moeraki, Otago, on 9 Feb 2024 (UBR 2024/016) was identified from photographs as a juvenile white-fronted tern (*Sterna striata*).

Arctic tern (*Sterna paradisaea*)
Five reported 30–50km west of Rakiura/Stewart Island on 15 Apr 2023 (UBR 2023/125), and one in Queen Charlotte Sound, Marlborough Sounds, on 11 Oct 2023 (UBR 2024/025).

Antarctic tern (*Sterna vittata*)
One reported from Waitarakao/Washdyke Lagoon, south Canterbury, on 28 Dec 2022 (UBR 2023/024), and one from Te Waihora/Lake Ellesmere outlet, Canterbury, on 27 Feb 2024 (UBR 2024/066).

Kerguelen petrel (*Lugensa brevirostris*)
Fifteen reported off Cape Palliser, Wairarapa, on 29 Jun 2021 (UBR 2023/077), and one from the Abel Tasman Track, Tasman Bay, on 12 Feb 2023 (UBR 2023/071).

Pycroft's petrel (*Pterodroma pycrofti*)
Two reported off the Canterbury coast on 17 Dec 2022 (UBR 2023/022), and one 25 km south of the Snares Islands/Tini Heke on 3 Jan 2023 (UBR 2023/029).

Salvin's prion (*Pachyptila salvini*)
One reported at South Traps Reef, south of Rakiura/Stewart Island, on 9 Jun 2023 (UBR 2023/080).

Black petrel (*Procellaria parkinsoni*)
One reported 15 km off Taiaroa Head, Otago, on 8 Oct 2023 (UBR 2023/108).

Little shearwater (*Puffinus assimilis*)
One reported off the Canterbury coast on 17 Dec 2022 (UBR 2023/021).

Whenua Hou diving petrel (*Pelecanoides georgicus whenuahouensis*)
One reported off Rabbit Island, Tasman Bay, on 11 Nov 2023 (UBR 2023/118) was identified as a Cape petrel (*Daption capense*) from the image provided.

Great frigatebird (*Fregata minor*)
A frigatebird seen at Collingwood-Pūponga Main Road, Golden Bay, on 30 Jan 2023 (UBR 2023/049) was accepted as a frigatebird species (*Fregata* sp.).

Masked booby (*Sula dactylatra*)
One reported at Pahi, Kaipara Harbour, on 19 Feb 2023 (UBRs 2023/013 & 2023/094).

Darter (*Anhinga melanogaster*)
One reported at New Brighton pier, Christchurch, on 22 Feb 2023 (UBR 2023/020).

Black shag (*Phalacrocorax carbo*)
One reported at Perseverance Harbour, Campbell Island/Motu Ihupuku, on 4 Dec 2023 (UBR 2024/001).

White-faced heron (*Egretta novaehollandiae*)
One reported at Port Ross, Auckland Islands/Motu Maha, on 28 Nov 2023 (UBR 2023/128).

Yellow-billed spoonbill (*Platalea flavipes*)
One reported at Waioeka River, Bay of Plenty, on 4 Feb 2024 (UBR 2024/029).

White ibis (*Threskiornis molucca*)
One reported at Manurewa, Auckland, on 24 May 2024 (UBR 2024/044).

Eastern osprey (*Pandion cristatus*)
One reported at Wade River Road, Whangaparāoa, on 24 Jan 2023 (UBR 2023/009).

Eastern marsh harrier (*Circus spilonotus*)
One reported at Waipu Cove, North Auckland, on 2 Nov 1996 (UBR 2024/028).

Laughing kookaburra (*Dacelo novaeguineae*)
One reported at Ngātīmoti, Motueka River, on 21 Jan 2023 (UBR 2023/006), and another at Waipara, North Canterbury, on 28 May 2023 (UBR 2023/067).

Rainbow bee-eater (*Merops ornatus*)
Two reported at Cockle Bay, Auckland, on 16 May 2023 (UBR 2023/065) were considered likely to have been sacred kingfishers (*Todiramphus sanctus*).

Nankeen kestrel (*Falco cenchroides*)
One reported at Lindis Valley, Otago, on 4 Feb 2024 (UBR 2024/019).

Rifleman (*Acanthisitta chloris*)
Two reported at Karekare, West Auckland, on 15 Mar 2024 (UBR 2024/063).

Blue-faced honeyeater (*Entomyzon cyanotis*)
One reported at Crofton Downs, Wellington, on 11 Nov 2024 (UBR 2024/097).

North Island kokako (*Callaeas wilsoni*)
One reported at Bledisloe Park, Palmerston North, on 11 Jun 2024 (UBR 2024/046) was considered likely to have been a kererū | New Zealand pigeon (*Hemiphaga novaeseelandiae*).

Hihi (*Notiomystis cincta*)
Two reported at Lake Moeraki, West Coast, South Island, on 4 Apr 2023 (UBR 2023/048) were considered likely to have been tomtits (*Petroica macrocephala*). One reported at Glenbrook, South Auckland, on 19 Oct 2024 (UBR 2024/088).

Tree martin (*Petrochelidon nigricans*)
One reported at Huapai, West Auckland, on 20 Jan 2022 (UBR 2024/067), and two reported at Lyell Valley, Buller, on 6 Jan 2024 (UBR 2024/003).

Unidentified bird
Two records submitted as unidentified birds were identified from photographs as an oil-stained red-billed gull (*Chroicocephalus novaehollandiae*, UBR 2024/083) and a grey warbler (*Gerygone igata*, UBR 2023/098).

DISCUSSION

The Records Appraisal Committee received 247 Unusual Bird Reports between January 2023 and December 2024, at an average rate of 10.3 per month. This was the highest reporting rate in the history of the reporting scheme (up from 9.2 per month received during 2017–18; Miskelly *et al*. 2019). Excluding one report of a 'non-reportable' species, a total of 194 UBRs were accepted (78.9%), which was similar to the acceptance rate of 79.5% for 880 submissions over the previous decade (Miskelly *et al*. 2015, 2017, 2019, 2021, 2023).

Common tern was the most-reported species during the 2-year period of 2023–24, with 16 UBRs received (and 14 accepted). Regular observations by an experienced observer on the Wellington west coast over the past four decades indicate that common terns are being seen more regularly and in larger numbers (Alan Tennyson, *pers. obs*). We therefore consider that the high reporting rate in

2023-24 was due to more common terns reaching New Zealand on migration, as well as birders are becoming more aware and proficient at searching for and identifying common terns among the very similar white-fronted terns that they generally associate with.

In addition to common tern, species reported (and accepted) in exceptional numbers in 2023–24 included 12 little tern UBRs and 10 for Australasian little grebe. The little tern records were all from the South Island, and have prompted the RAC to modify the 'reportable' status for little tern (it remains reportable for Rakiura/Stewart Island and outlying island groups). The Australasian little grebe reports were mainly from the South Island (eight UBRs from six localities), and were all between March 2023 and June 2024. Breeding has not been confirmed in the South Island since 1996-97, although breeding likely continued until about 2007 (Miskelly *et al*. 2015). The three birds present at Lake Murray, Tekapo, in January 2024, were considered to be adults (Rohan Clarke *in* UBR 2024-010a), and so were not evidence of breeding.

A feature of the 2023–24 reporting period was the large number of submissions arising from pelagic seabirding trips, including 20 UBRs from east of the Poor Knights Islands (trips organised by Scott Brooks), and five from the Papanui and Taiaroa Canyons off Otago Peninsula. Together, these trips were the source of about 10% of submitted UBRs, and 13% of accepted UBRs, with most of these 'pelagic' UBRs being supported by good quality photographs. These trips continue to improve our understanding of seabird distribution around New Zealand, with the most notable pelagic record during 2023–24 being the first live sighting (and second record) of streaked shearwater from New Zealand. They also provide evidence that some species are more regular in these areas than previously realised, which allows us to modify the reportable bird list accordingly, such as dropping Chatham Island albatross as a reportable species east of mainland New Zealand.

The most notable records during 2023–24 were the addition of Horsfield's bronze-cuckoo, MacGillivray's prion, and the Asian subspecies of gull-billed tern (*G. n. affinis*) to the New Zealand list. The circumstances of discovery and the significance of the cuckoo and prion records have been reported elsewhere (Galbraith & Gill 2025; Miskelly *et al*. 2025). *G. n. affinis* is a regular migrant to northern Australia, straying as far south as New South Wales, Victoria, and South Australia (Lilleyman & Hensen 2014; Menkhorst *et al*. 2017). It is smaller than the Australian-breeding *G. n. macrotarsa*, with a smaller bill, and a smaller black eye-patch when in non-breeding plumage (Rogers *et al.* 2005; Lilleyman & Hensen 2014; Menkhorst *et al*. 2017). Note that *macrotarsa* is sometimes treated as a full species, with the common name of Australian tern (Mlodinow 2023).

The addition of Horsfield's bronze-cuckoo and MacGillivray's prion increases the number of bird species recorded naturally from New Zealand since AD 1800 to 362 (Checklist Committee 2024; Miskelly *et al*. 2024). Of these, 16 are considered extinct. In addition, 35 introduced species are currently considered established in the wild in New Zealand, making the current avifauna 381 species (including 25 migrant species that breed elsewhere, and 143 vagrant species; see Townsend *et al*. 2008 for definitions).

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Speculations about southern mergansers (*Mergus* spp.): life history and ecological characteristics inferred from kindred species

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Abstract: Life history and ecological characteristics of extant mergansers (Tribe Mergini) are summarised and used to infer those likely displayed by the extinct merganser from "mainland" New Zealand (*Mergus* sp. indeterm.). I speculate this was a river-dwelling species, plausibly a year-round territorial occupant of mid-lower reaches of rivers, whose subadults and non-breeders may have aggregated seasonally on broad lower reaches, including estuaries. Of extant mergansers, its ecology was probably most similar to that of Brazilian merganser (*Mergus octosetaceus*). Holocene sea-level rise and loss of habitat may have induced changes in social structure of Chatham Island merganser. A plausible life history and ecological template, however speculative, can aid evaluations arising from other sources of evidence e.g. locations of fossils and bone stable isotope chemistry.

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INTRODUCTION

A merganser (*Mergus* sp.) in the New Zealand archipelago is, by any measure, a biogeographic oddity. Mergansers ("sawbills"), a small clade within the "sea ducks" (Tribe Mergini), are of Northern Hemisphere origin, based on Miocene representation (Alvarez & Olsen 1978). Today, they comprise six extant species of *Mergus* (4), *Lophodytes* (1), and *Merganellus* (1), the latter genus alternatively rooted at the split of the *Bucephala* (goldeneye) and merganser clades (Livezey 1995) or having diverged early from the merganser clade (Buckner *et al*. 2018). Their present-day distributions are confined to the boreal and temperate regions of the Euro-Siberian palearctic and to the boreal region of North America with but one exception, the Brazilian merganser (*Mergus octosetaceus*), which is now of remnant distribution on rivers within Brazil's Atlantic forests after having recently disappeared from former enclaves on rivers further south in Paraguay and Argentina (Hughes *et al.* 2006; Lamas & Lins 2020; Campos *et al.* 2023).

Whereas a merganser in South America is evidence of a historic trans-hemispheric crossing, plausibly aided by a land connection and forest-edged riverine pathways, a merganser in the isolated New Zealand region implies an historic, and heroic, trans-hemispheric, trans-oceanic crossing, the when, from where, and by which taxon, continuing to prompt both speculation (e.g. Johnsgard 1960, 1965) and ongoing inquiry (e.g. Livezey 1995; Rawlence *et al.* 2024). Establishing a waif-founded population – as Livezey (1995) colourfully described it – also implies persistent and closely timed arrivals, or an *en masse* founding event, both of which have been rare outcomes in the establishment of New Zealand's land and freshwater avifauna other than from an Australian source (Falla 1953; Trewick & Gibb 2010). With no evidence of an historic merganser presence in Australia, the possibilities of a prolonged oceanic crossing, or of an island-hopping colonising route, most plausibly from a Northern Hemisphere source (Rawlence *et al.* 2024), remain conjectural.

Once established on the New Zealand archipelago, mergansers differentiated. A population, undoubtedly small throughout Holocene times, occupied the subantarctic Auckland Islands, 450 km south of New Zealand and from which it was exterminated, in 1902, following rapacious specimen collecting (Kear & Scarlett 1970; Williams 2012). Another population established on Chatham Island, 800 km east of New Zealand, where, in isolation, it differentiated measurably from those occupying Auckland Islands sufficient to be regarded as a separate taxon (Williams *et al.* 2014).

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It became extinct, most likely from predation by initial Polynesian settlers given that merganser bones have been found in their middens (Sutton & Marshall 1977; Millener 1999). Polynesian settlers, Maori, on the main islands of New Zealand also encountered and ate mergansers. Although merganser bones have been a rare find in Maori midden deposits on North, South and Stewart Islands (Millener 1981; Worthy 1998a,b; Williams *et al.* 2014), predation by Maori, possibly aided by their commensal dog, kuri (*Canis familiaris*), has been proposed as the cause of the merganser's extinction there (Worthy 1999; Tennyson & Martinson 2006). Their former presence was unknown until a mandible was extracted from a midden at Wairau Bar, Marlborough, in 1945 (Kear & Scarlett 1970).

Collectively, the mergansers of the New Zealand region may be referred to as southern mergansers, a name of historic origin – *Harle australe* – applied at the time of initial description (Hombron & Jacquinot 1841). Presently, they are viewed as two species-level taxa: Auckland Island merganser (*M. australis*) and Chatham Island merganser (*M. milleneri*), while the taxonomic status of mergansers on the New Zealand "mainland" (hereafter 'New Zealand merganser') remains unresolved (Checklist Committee 2022), as do the modes of each population's establishment and their relationships with each other. Future taxonomic revision, possibly involving recognition at subspecific level, seems inevitable.

Unaddressed by the current determination to unravel ancestral relationships of southern mergansers is how the birds may have lived, e.g. what habitats were occupied, what foods were consumed, what mating system was displayed? In short, what might have been their life history and ecological characteristics? These questions are explored here.

Drawing initially on Lyell's dictum (Lyell 1864) that (paraphrasing) the past can be explained by reference to contemporary processes, I seek to identify life history and ecological commonalities across all extant sawbills (hereafter 'mergansers') and identify those which can be plausibly imagined as having been displayed by southern mergansers. The implicit assumption is that phylogeny reflects a common ecology, albeit with local adaptations to reflect differing faunistic associations and environmental vicissitudes, and that what is common to all extant mergansers, southern mergansers would have shared.

This approach is a necessary first step to aid future research on, and interpretation of, southern mergansers because they have left a very faint trail. Chatham Island mergansers are known from a fortuitous aggregation of bones from females which nested and became entrapped within a single small cave, from a scattering of 11 wing and leg bones found exposed on the island's sand dunes, and by four bones excavated from middens (Millener 1999; Williams *et al.* 2014). Auckland Island mergansers are known from 27 specimens collected between 1840 and 1902 (Williams 2012), and from four bones found exposed on a sand dune deflation (Tennyson 2020). New Zealand mergansers are represented by bones excavated from seven Maori middens, from three bone aggregations considered to be natural deposits, and four bones found exposed on dune deflations (Worthy & Holdaway 2002; MW *unpubl.*). These locations of bone discovery offer evidence of a former North, South, and Stewart Island distribution, but not of habitat. To date, stable isotope analyses of two bones have

Table 1. Habitats occupied by extant mergansers. Summarised from species accounts in Cramp & Simmonds (1977), Kear (2005), and del Hoyo *et al.* (2020).

Taxon	Breeding	Non-breeding/winter
Goosander	Freshwater lakes, rivers and streams in boreal forested areas, preferring upper basins of rivers and large clear inland lakes. Will use deeper waters and tolerates reaches of fast flow. Seasonal occupancy. Non-territorial.	Predominantly freshwater, on lower latitude lakes, reservoirs and rivers. Sometimes coastal bays and estuaries.
Scaly-sided	On forested-margined, clear, fast-flowing mountain rivers and rapid streams with many shingle spits and islands, in taiga zone; typically, far from human habitation. Seasonal occupancy. Territorial.	Freshwater, most wintering on ice-free lakes, reservoirs, more sluggish rivers and lagoons, but some remain on clear fast-flowing rivers in hilly and mountainous areas, with low disturbance levels (China and Korea) and a small percentage undertakes moult migration to brackish and marine waters (Sea of Japan).
Red-breasted	Sheltered saltwater areas. Riverine occupancy increases with decreasing gradient and prefers slower, smoother river sections. Tundra and boreal forest zones on fresh, brackish, and saltwater wetlands with sheltered bays. Seasonal occupancy. Non-territorial.	Marine. Winters predominantly on secluded bays or estuaries in marine environments where protected areas provide calm seas.
Brazilian	Clear meandering streams with occasional rapids within savannah and subtropical forest, often above waterfalls. Year-round occupancy. Territorial.	Within breeding territories and in areas of unoccupied riverine habitat.
Hooded	Forested lakes, ponds, rivers and streams with clear water (sea-level. to 1180 m asl) across northern-eastern USA and southern Canada. Seasonal occupancy (non-territorial) of central breeding range but year-round in climatically milder eastern range.	Along both coasts, favours forested freshwater wetlands, ponds, brackish estuaries, and tidal creeks, where they often concentrate along the edge of ice.
Smew	Freshwater lakes, pools, slow-flowing rivers and muskegs in taiga zone during breeding season, with preference for lowland oxbow lakes amid forest (including drowned trees), especially within medium-sized valleys, and oligotrophic lakes and rivers with nearby forest in montane or submontane regions. Seasonal occupancy. Non-territorial.	Winters mainly on larger lakes, ice-free rivers, coastal brackish lagoons and estuaries. Uncommonly on open sea and rarely in water more than c. 6 m deep.

provided equivocal indications of diet and feeding realm (Williams *et al.* 2012).

Thus, beyond what this minimal aggregation of remains might be able to convey *per se*, common characteristics of kindred mergansers may provide inferences of key life history and ecological characteristics of southern mergansers. Of particular relevance would be (i) habitat(s) occupied, especially when breeding and whether on rivers, lakes, or in coastal environments; (ii) foods consumed, and the relative importance of fish and invertebrates; (iii) features of breeding biology including whether pair bonds renew annually, whether nesting or territorial philopatry is demonstrated, and whether males contribute parental care; and (iv) any seasonal dispersion including for the wing moult, throughout winter, and of subadults in their pre-breeding years.

KINDRED MERGANSERS

Extant mergansers, in order of descending body mass, are goosander or common merganser (*Mergus merganser*), scaly-sided or Chinese merganser (*M. squamatus*), red-breasted merganser (*M. serrator*), Brazilian merganser, hooded merganser (*Lophodytes cucullatus*), and smew (*Mergellus albellus*). Their distributions, and details of their sexual dimorphism in plumage and body sizes, are well documented (Kear 2005; del Hoyo *et al.* 2020), and attest to southern mergansers being the most geographically isolated and, at an estimated 550-760g (Williams 2012), the smallest *Mergus,* and approaching the conspicuously smaller hooded merganser and smew in body size.

Habitats

The five Northern Hemisphere mergansers are characterised by their seasonal occupancy of different habitats, whereas the Brazilian merganser is a year-round river resident (Table 1). Freshwaters are the primary environment for all. Breeding habitat is typically forest-edged watercourses or secluded lake shores throughout the boreal region, some extending into sub-arctic waterways. The red-breasted merganser is the only species known sometimes to breed in or adjacent to saline water and has been recorded nesting amongst colonial-nesting seabirds on near-shore islands (Craik *et al.* 2020).

Ice-free freshwaters comprise the main winter habitats of all northern mergansers, requiring some extensive seasonal migrations. All except hooded merganser have been recorded sometimes aggregated in protected coastal or estuarine locations for their annual wing moult and persisting there during hard winters (del Hoyo *et al.* 2020).

Foods and feeding

All mergansers consume both fish and aquatic invertebrates in all of their habitats (Table 2). Feeding on fish commonly involves scanning from the water surface before diving, the prey being consumed at the surface rather than underwater. Fossicking for invertebrates occurs from the surface in shallow water, or by prolonged dives in deeper water. The relative importance of these two food categories has not been well established except that all feeding studies report a mixed diet but, depending on sampling time or place, may be dominated by one food type. For ducklings of all species, sessile and motile invertebrate prey are the primary foods until they are about half-grown. Uniquely, Brazilian mergansers will feed fish to their ducklings. Co-operative feeding, which assists the capture of fast-moving schooling fish, has been reported for all northern mergansers when aggregated as flocks.

Life history and breeding characteristics

All extant mergansers first attempt to breed in their second year, or later (Table 3). Their delayed maturity has the likely correlate of extended longevity, although data to support this assumption are sparse for all species. Seasonal monogamy is common to all northern mergansers, with pairings being established during spring migration or on the breeding grounds. Males of these species abandon their mates from midway through the incubation period (30–34 days), and well before hatching. Females alone provide parental care. Nesting is mostly in tree holes or root boles, and some nest sites are occupied in consecutive years. Amalgamation of broods occurs amongst neighbouring river-dwelling families but has not been reported in the more spatially dispersed hooded merganser and smew.

Female breeding area fidelity is well attested for red-breasted mergansers (Craik *et al.* 2020) and is implied by records of some goosander (Eriksson & Niittylä 1985),

Table 2. Foods of extant mergansers. Summarised from species accounts in Cramp & Simmonds (1977), Kear (2005), and del Hoyo *et al.* (2020).

Taxon	Saline/Marine		Freshwater	
	Invertebrates	Fish	Invertebrates	Fish
Goosander	Large benthic prey taken.	Predominantly piscivorous. Co-operative feeding.	Larger benthic prey taken but seemingly as a supplement.	Predominantly piscivorous, no obvious prey selection although salmonids feature in many analyses.
Scaly-sided	Large benthic prey probably taken.	Predominantly piscivorous. Co-operative feeding.	Diurnal feeder, taking mainly small fish and aquatic invertebrates.	
Red-breasted	Large benthic prey, including crustacea and worms.	Predominantly piscivorous. Co-operative feeding.	Unselective, gleans caddis, small crustacea, worms.	Predominantly piscivorous.
Brazilian	Marine habitats not occupied		Extensively	Extensively
Hooded	Yes	Yes	Insects, crustacea (particularly crayfish),. more so than other mergansers.	Primarily fish and crustaceans.
Smew	Annelids, crustacea, rarely small bivalves.	Any small fish. Flock feeding in winter across sandy sea floors.	Most aquatic invertebrates (water beetles, dragonflies, caddis larvae).	Both pelagic and bottom-dwelling species.

Table 3. Breeding characteristics of mergansers. Summarised from species accounts in Cramp & Simmonds (1977), Kear (2005), and del Hoyo *et al.* (2020). n.d. = no data.

Taxon	Year of first breeding	Mate fidelity	Clutch size	Incubation (days)	Nest site	Parental care	Brood amalgamation
Goosander	2nd	Seasonal monogamy	8–11	30–32	Tree and other cavities	Female only	Common
Scaly-sided	2-3	Seasonal monogamy	10–11	31–35	Tree cavities	Female only	Common
Red-breasted	2nd	Seasonal monogamy	8–10	31–32	Concealed ground sites	Female only	Common
Brazilian	n.d.	Long-term monogamy	5–8	c.33	Tree and ground cavities	Bi-parental	Not reported
Hooded	2nd	Seasonal monogamy	9–11	29–33	Tree cavities	Female only	Not reported. Frequent nest parasitism
Smew	2nd?	Seasonal monogamy	7–9	26–28	Tree cavities	Female only	Not reported. Nest parasitism referenced

hooded merganser (Duggar *et al.* 2020), and scaly-sided merganser (Zhaio *et al.* 1995) females reusing nest cavities, or nesting again nearby.

Brazilian mergansers are distinguished from their northern counterparts by occupying and defending their breeding territories throughout the year. This behaviour is accompanied by enduring multi-year pair bonds, shared parental care of offspring, and prolonged retention of fledglings within their natal areas. They are also distinguished by their extensive feeding ranges and low-density occupation of their riverine habitat.

Seasonal dispersion

Adult males and females of northern mergansers have different patterns of seasonal dispersion. After abandoning females on the breeding grounds, males migrate to (mostly) sheltered coastal locations to undergo their annual wing moult, before dispersing again ahead of winter ice formation. Females of most species also assemble in moult aggregations, but mostly at freshwater sites closer to breeding areas. From there they disperse back to breeding areas by following the spring ice retreat (species accounts in del Hoyo *et al.* 2020).

Delayed maturity results in subadults (young of the previous year) being present in loose aggregations at moulting and breeding sites. Small flocks sometimes assemble on river sand bars from where they move at length up and down rivers to become familiar with occupied and potential breeding habitats.

Commonalities and differences

Multiple characteristics differentiate the Brazilian merganser from the others. Northern Hemisphere mergansers have ecologies and life histories shaped by their seasonal occupation of breeding habitat on woodland-margined freshwaters (including river segments comprising pool/riffle systems with swift-flowing or turbulent water), commencing from when the spring thaw is advanced enough to offer ice-free waters in which to feed, and by the subsequent seasonal necessity to seek ice-free winter refuges. Seasonal monogamy and female-only parental care characterise this life history, as do long migratory flights to communal moulting and feeding sites, some of which include saline environments.

By contrast, Brazilian mergansers are year-round occupants of their present-day tropical rain forest riverine habitat, and long-term breeding partnerships are indicated. Even so, many of their life history and ecological characteristics e.g. delayed maturity, tree hole nesting sites, swift-flowing riverine breeding habitat, and food diversity, mirror those of northern mergansers, and are indicative of the transfer of basic life history traits into a warmer, wetter, and snowless environment. This being so, the Brazilian merganser may model how southern mergansers, in their temperate environments, may have lived.

There is an important proviso, however. Presently, Brazilian mergansers have a remnant distribution. Descriptions of all persisting population isolates as occupying habitat of "rapid, torrential streams and fast-flowing rivers usually fringed by dense tropical forest, typically selecting rivers > 1 m deep and > 3 m wide, though after rains, when main rivers may become turbid with sediment, apparently uses shallow streams just *c.* 50 cm deep and 2–4 m wide" (Carboneras *et al.* 2018), may not necessarily reflect optimal habitat requirements, nor that of former habitats now alienated (Gray & Craig 1991; Lomolino 2023). Similarly, interpretations of breeding density e.g. "territory size (of multiple kms length) believed to be related to number of rapids, edge waters, water speed, fish abundance and conservation of riparian vegetation" (Carboneras *et al.* 2018), may also reflect the small sizes of present populations. These disjunct remnant populations have not yielded evidence of inter-catchment dispersal or settlement, nor of dispersal beyond forest-fringed waterways. Review literature makes no reference to Brazilian mergansers inhabiting lakes or impoundments. Some Brazilian rivers on which they occur have been modified by small hydro dam construction and water impoundments. Mergansers are absent from these lentic environments (Bovo *et al.* 2021).

Nonetheless, the critical conservation status of the Brazilian merganser has fostered multiple studies of its life history and reproductive characteristics, including those of Bruno *et al.* (2010), Vilaca *et al.* (2012), and Ribiero *et al.* (2018), and all have highlighted the merganser's multi-year site occupancy and territoriality, enduring mating relationships, a diminished mean and range in clutch size relative to northern mergansers, bi-parental brood care, and the prolonged presence of young within their natal range, hinting at natal philopatry and confirming delayed onset of breeding.

SPECULATIONS ABOUT THE NEW ZEALAND MERGANSER

The following speculations about the New Zealand merganser are based on the preceding summaries of contemporary merganser life histories and ecological characteristics, and the contrasts between those of the Brazilian and northern mergansers.

Habitat
New Zealand mergansers occupied forested-edged rivers as breeding habitat.

All extant mergansers occupy forest-edged riverine habitat that includes pool/riffle systems thus indicating an ability to capture or glean prey in swift-flowing or turbulent water. If such areas of New Zealand rivers had a year-round abundance of small fish (for it seems unlikely that southern mergansers could have been sustained by a diet solely of freshwater invertebrates), mergansers might have occupied mid-gradient (10–25 m/km) segments of rivers well inland, perhaps even occupying some waters in which whio/blue duck (*Hymenolaimus malacorhynchos*) might also have occurred. Like other *Mergus* species, they were likely dispersed at low density (multiple kms/pair).

Mating system
New Zealand mergansers maintained year-round and exclusive occupancy of their breeding habitats and maintained pair associations year-round. Bi-parental brood care, or at least male brood attendance, would have occurred and both adults would have undertaken their annual wing moult within their breeding range.

This speculation directly reflects the Brazilian merganser's mating system and assumes the breeding habitat provided sufficient food resources to support autumn-winter occupancy (see below). It also reflects characteristics common to most other riverine waterfowl (Williams & McKinney 1996), especially those occupying habitat hazardous to ducklings. In these respects, the mating system of the New Zealand merganser may have been similar to that of whio/blue duck, New Zealand's other riverine waterfowl (Williams 2013).

Life history
Breeding was delayed until at least the second year, and subadults comprised an itinerant component of the population.

Delayed maturity is a characteristic of all extant merganser species. In common with many other waterfowl species with delayed maturity (Oring & Sayler 1992), subadults would have traversed breeding habitat and interacted with resident breeders. They were also likely to have co-assembled in non-breeding habitat, there to feed and undergoing their wing moults collectively. These habitats would have included river deltas and their estuarine zones, especially during times of fish migrations.

Fish resource
Freshwater fishes in rivers of pre-human New Zealand were sufficiently abundant, year-round, to support an avian piscivore.

Of the 38 fishes native to New Zealand, about half spend part of their life histories, as juveniles, in the sea (McDowall 1990), and most reach the rivers in large spring-time migrations. Thereafter, upstream movements disperse species to a variety of watercourses, large, small and occluded, and those species with climbing abilities circumvent obstacles to reach headwaters. Likely biomass in rivers prior to human settlement can only be surmised; however, some species were so profoundly abundant, especially when migrating, that they provided a plentiful and reliable seasonal food resource for Maori (McDowall 2011; Anderson 2025), especially eels (Family Anguillidae), grayling/upokororo (*Prototroctes oxyrhynchus*: Retropinnidae), and multiple species of "whitebaits" (Family Galaxiidae). Conspicuous amongst the latter were inanga (*Galaxias maculatus*), koaro (*G. brevipinnis*), and kokopu (*G. argenteus*). Early European accounts (as interpreted by McDowall 2011) indicate an abundant year-round presence of eels, grayling, and koaro in segments of rivers 'modest distances inland', while koura/freshwater crayfish (*Paranephrops planifrons, P. zealandicus*) were probably then common and abundant.

POSSIBLE INDEPENDENT ADAPTATIONS OF CHATHAM ISLAND AND AUCKLAND ISLAND MERGANSERS

Whereas northern mergansers probably responded to the successive Pleistocene era advances and retreats of ice sheets across their continental ranges by moving south or north with them, southern mergansers faced significant expansion or diminution of landscape in response to associated sea level changes. For example, the dramatic rise of sea level since the last glacial maximum (Clarke *et al.* 2009) drowned extensive lowland riverine habitat within the ranges of all three southern mergansers. Using the present-day 120 m seafloor contour as a proxy for likely shoreline at the last glacial maximum (21-18,000 years before present), land areas of Chatham and Auckland Islands have each been reduced by *c.* 88% and New Zealand itself by *c.* 35% (D. Strogen, *pers. comm*.). The New Zealand mainland was also cleaved into its present three main islands.

At Chatham Island, such extensive loss of most riverine and estuarine habitat probably greatly diminished the merganser population. Sea-level stabilisation, from about 6,000 BP, allowed the formation of the shallow but extensive (160 km^2) Te Whanga Lagoon, thereby providing an essential, possibly primary, estuarine refuge for the mergansers. Whether in response, or already a prior adaptation, Chatham Island mergansers displayed an obvious tolerance for feeding in marine and estuarine waters. Their skulls bear prominent supra-orbital salt gland impressions (Williams *et al.* 2014: Fig 3), visibly larger and more conspicuous than on the skulls of northern mergansers (viewed at https://skullsite.com). Bone stable isotope measurements from three mergansers which nested alongside the lagoon confirmed a saline feeding environment and a diet probably dominated by piscivorous fish (Williams *et al.* 2012).

Dependence on foods from expansive and featureless marine/estuarine environments would probably have required a social structure different from that shown by all extant river-breeding mergansers, or that speculated for New Zealand mergansers. Exclusive resource acquisition and defence of a fixed area, even just seasonally, would likely have proven unobtainable, just as it is for many waterfowl whose feeding environments are widely distributed, including as multiple small patches e.g. many *Anas* ducks (Baldassare & Bolen 2006). Chatham Island mergansers might have made significant behavioural changes as part of their adaptation to a rapidly changing and shrinking Holocene feeding environment.

At Auckland Island, its landscape has long been dominated by steep and truncated glaciated valleys descending its eastern flank. Holocene sea-level rise (implied by the 120 m seafloor contour) inundated formerly extensive north-eastern lowland and associated meandering waterways. No coastal waters protected from the endless westerly or southerly tempests remained, except at the very heads of most eastern valleys, or along short sections of Carnley Harbour. During its brief period of human encounter (1840–1902), the Auckland Island merganser was a rarity, observed only within some short, steep valley streams and their immediately adjacent coastal fringes (Williams 2012). Although stable isotope measurements of its bones, claws and feathers indicate both freshwater and marine-sourced foods, salt gland

impressions are barely discernible on its skull (Williams *et al.* 2012). By having occupied discrete and delineable habitat, Auckland Island mergansers may have evinced a social structure and mating system akin to those suggested for the New Zealand merganser, albeit in very small numbers. The only two broods of ducklings observed were each accompanied by two adults (Williams 2012).

CONCLUSIONS

Whereas, at the time of first human settlement, Chatham Island's and Auckland Island's merganser populations were small and largely restricted to habitats and foods in estuarine and saline waters, I speculate that New Zealand's merganser was a riverine species. In common with all extant *Mergus*, its breeding pairs were probably dispersed at low density along low to mid gradient reaches. Subadults and non-breeders, in addition to traversing breeding areas, would likely have aggregated, seasonally or persistently, on more extensive lowland reaches and any associated estuary. Of extant mergansers, the life history and ecological characteristics of Brazilian merganser, remnant populations in small refugia though this species now comprises, can provide a useful model for interpretating the ecology of New Zealand mergansers garnered from other sources, such as middens and natural deposits of merganser bones, and evaluations of bone protein isotope chemistry.

New Zealand's other endemic river-dwelling waterfowl, whio/blue duck, is particularly rare as a fossil, and although found in cave deposits, arising from its habit of fossicking seepages and trickles beyond watercourses (Worthy & Holdaway 2002), it has not yet been retrieved from midden deposits. Nor was it recovered from the only two lacustrine deposits reported (Pyramid Valley, Holdaway & Worthy 1997; Lake Poukawa, Worthy 2004).

Although merganser bones were found in the Lake Poukawa deposit, perhaps a tantalising hint of another habitat exploited, it has been the rare recovery of merganser bones in estuarine-edge Maori midden deposits (Kear & Scarlett 1970, Worthy 1998a; Worthy & Holdaway 2002) that has prompted a prevailing interpretation of the New Zealand merganser being a coastal and marine inhabitant (e.g. Heather & Robertson 1996; Worthy1998a,b; Tennyson & Martinson 2006). Locations of Maori midden deposits reflect human choice of occupation site. Whether foods were gathered locally or more widely is difficult to determine. While avian species composition in middens might indicate the immediate environments from which food was collected, relative species abundance is more problematic to interpret (Scofield *et al.* 2003; Worthy 1999). For any interpretation, the challenge is to separate human agency from natural phenomena, a challenge perhaps aided by the question 'what aspect of this merganser life history or ecology might have allowed bones to accumulate here?' This is especially relevant to sites near middens yet deemed to be natural deposits and from which bones of multiple merganser individuals have been extracted e.g. Marfells Beach, Native Island, and Lake Poukawa (Worthy 1998a,b, 2004). Stable isotope analyses of these bones, in conjunction with secure understanding of their provenance, can test the speculative inclusion of this merganser as a member of New Zealand's endemic freshwater avifauna.

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SHORT NOTE

Signs of hybridisation? A red shining-parrot (*Prosopeia tabuensis*) with mixed traits in a masked shining-parrot (*P. personata*) flock on Viti Levu, Fiji

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Fiji is an island nation in the South Pacific and home to three large parrot species: the red or maroon shining-parrot (*Prosopeia tabuensis*), endemic to the northern islands (Vanua Levu, Taveuni, Koro, and Gau); the masked shining-parrot (*P. personata*), restricted to the forests of Viti Levu; and the crimson shining-parrot (*P. splendens*), endemic to Kadavu and Ono in the south. All three species are large, robust parrots with long tails, strong bills, and generally bright, iridescent plumage. The red shining-parrot is also found in Tonga. Two subspecies of *P. tabuensis* are recognised: *P.t. tabuensis* (Vanua Levu, Kioa, Koro, Gau, Eua (Tonga)) and *P.t. taviunensis* (Taveuni, Qamea, Laucala) (Collar & Boesman 2020).

Unlike the masked and crimson shining-parrots, which are both listed as Near Threatened (BirdLife International, 2023a & b), *P. tabuensis* is currently considered Least Concern with a decreasing population trend (BirdLife International 2018). It occurs in a range of habitats, including forests, shrublands, mangroves, village gardens, and artificial habitats, such as coconut plantations (Collar & Boesman 2020). Its presence on Viti Levu was described by Watling (2004) as 'a small number of Kadavu and Red Shining Parrots survive on Viti Levu, almost certainly as escapees or deliberate releases of unwanted cagebirds brought from the outer islands, because they are regularly, but illegally, taken as pets'. More recent sightings included one in 2002 near the current study area (Vilikesa Masibalavu, *pers. comm*.).

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Here, I report three separate observations with photographs of what appears to be the same red shining-parrot individual associating with a flock of masked shining-parrots. A fourth sighting of likely the same individual is recorded on iNaturalist (https://www.inaturalist.org/observations/150634427), and a fifth on eBird (https://ebird.org/checklist/S267937035). All observations took place in Colo-i-Suva Forest Park, a mid-elevation tropical rainforest located on the southeastern side of Viti Levu near the capital Suva. The area is characterised by dense canopy cover, a mix of native and introduced vegetation, steep terrain, and freshwater streams. The park supports a range of forest-dwelling bird species and provides foraging and roosting habitat within a relatively undisturbed setting. Based on a combination of plumage traits, I propose that the individual presented in this short note may be a hybrid between a masked shining-parrot and red shining-parrot.

All photographs were taken with a Nikon Z8 and Nikkor 800 mm lens during clear weather conditions, providing documentation for each encounter (Figs 1–3). The first observation took place at approximately 18.0650°S 178.4690°E on 1 Sep 2024 at 08:25. A single red-bodied parrot was seen perched on a branch (Fig. 1A). Shortly after, two masked shining-parrots flew past and were followed by the red individual (Fig. 1B). The second sighting occurred on 8 Jun 2025, within 100 m of the first location, around 08:00. A flock of six or seven masked shining-parrots was observed foraging and vocalising. The red individual was perched within 2 m of one of these birds (Fig. 2 A&B). The flock remained in the area for approximately 20 min before flying out of sight. A third observation occurred on

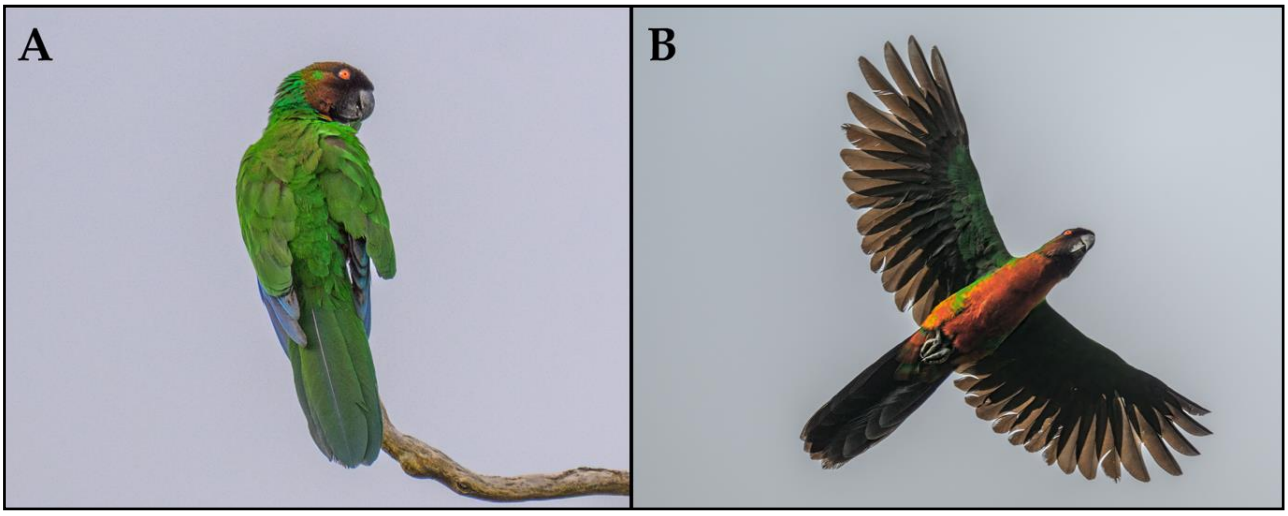

Figure 1. Potential hybrid *Prosopeia* parrot perched (A) and in flight (B). Photos taken on 1 Sep 2024 in Colo-i-Suva Rainforest Park around 08:00.

Figure 2. (A) Potential hybrid *Prosopeia* parrot (right) < 2 m from a masked shining-parrot (*P. personata*). (B) Back profile of the same individual. Photos taken on 8 Jun 2025 in Colo-i-Suva Rainforest Park between 08:00 and 08:30.

13 Jul 2025 around 08:26, approximately 700 m from the previous sightings. The red individual again appeared shortly after a masked shining-parrot was observed foraging nearby (Fig. 3).

The bird displayed a unique phenotype combining traits typical of both *P. tabuensis* and *P. personata* (Fig. 3). It exhibited a deep maroon body and undertail coverts consistent with *P. tabuensis* but showed a sharply defined blackish face and the green nape extending unusually high, more typical of *P. personata*. While dusky facial markings are occasionally seen in *P. tabuensis*, this degree of contrast is uncommon. Most notably, the bird exhibited a small green patch above the cheek on both sides of the head — a feature not previously documented in either species and absent from image databases on eBird, iNaturalist, or other references. The individual lacked the blue edging of the outer greater coverts that is typical of *P. tabuensis*, and also lacked a blue nuchal collar, although some individuals of *P. tabuensis*, especially the subspecies *taviunensis*, lack this collar. The tail was washed-out green with a slight bluish tinge, again aligning more with *P. personata* than with the usual plumage of *P. tabuensis* (Collar & Boesman 2020). Also notable were irregular green blotches on the lower belly and legs.

A search of the citizen science platforms iNaturalist (https://www.inaturalist.org) and eBird (https://ebird.org/home) provided two additional sightings of likely the same individual, on 9 Mar 2023 (iNaturalist ID 150634427) and 17 Aug 2025 (ebird checklist S267937035), with the bird identifiable by its distinctive green head patch. No comparable wild records were found, and I could not find any locations where these birds are kept together and have the possibility to interbreed. An escape from captivity remains the most likely theory for the bird's origin; however, the sustained presence of this individual over 28 months, combined with its integration into native flocks and observed social behavior, indicate that this individual is an established free-living bird.

This unusually-plumaged parrot may represent the first documented case of hybridisation between *P. personata* and *P. tabuensis*, although this remains speculative without genetic confirmation. While hybridisation between *Prosopeia* species has not been previously reported, it is frequently reported among closely related parrot species (McCarthy 2006) and may be underreported in Fiji due to limited field observations and taxonomic uncertainty. A recent review by Hingston (2021) identified multiple cases of natural hybridisation in parrots, particularly within

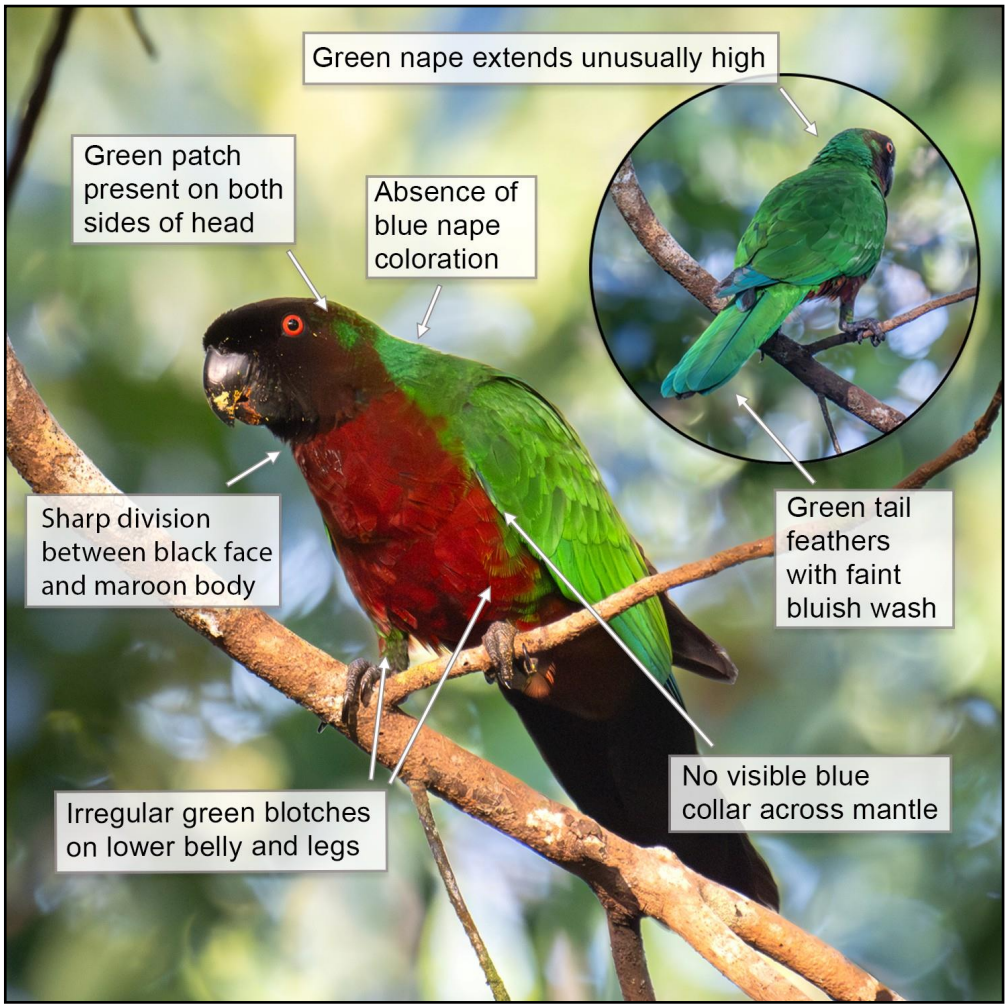

Figure 3. Labelled images of a potential hybrid individual *Prosopeia* parrot showing plumage traits characteristic of both *P. tabuensis* and *P. personata*. The bird was observed at Colo-i-Suva Rainforest Park, Viti Levu, and exhibited a combination of atypical features, including a green patch on both sides of the head, a sharp division between the black face and maroon body, absence of the blue nuchal collar, faint bluish wash on the tail feathers, and irregular green blotches on the lower belly and legs. The outer greater coverts lack the typical blue edging, and the green nape extends unusually high. The inset shows the same individual from the rear. Photographed on 13 Jul 2025.

the same genus, often occurring where species ranges overlap or have been altered by habitat change or human influence. Despite being geographically separated in their native ranges, *Prosopeia* species share ecological similarities and vocal behaviours that may facilitate interspecific interactions under such conditions. The individual's integration into a resident parrot flock may pose potential risks to the genetic integrity of Fiji's endemic parrot populations. While further evidence, particularly genetic analysis, is needed, this observation provides a glimpse into potential interspecific interaction and highlights the value of continued monitoring in biodiversity-rich yet data-deficient regions such as Fiji.

I thank the contributors to iNaturalist and eBird for maintaining invaluable citizen science platforms that aid in tracking rare or unusual observations. I also thank Steve Debus for reading through the draft manuscript, Vilikesa Masibalavu and Mark O'Brien for reviewing the first iteration of this short note, and Dick Watling and Colin Miskelly for their comments on the second revision.

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SHORT NOTE

Implications of possible production trends in radiocarbon measurements on *Pachyornis* moa (Aves: Dinornithiformes) from the Glencrieff site, north-eastern South Island, New Zealand

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The fossil collections from the site at Glencrieff (42°58′08″S 172°34′03″E), North Canterbury, provide evidence for the species composition of, and perhaps relative numbers in, moa populations in the glacial-interglacial period in that area (Worthy & Holdaway 1996; Rawlence *et al.* 2011). Three taxa, *Dinornis robustus* (Dinornithidae), a *Pachyornis* sp. that Rawlence *et al.* (2011) report as *P. elephantopus*, and *Emeus crassus* (both Emeidae) were certainly present, with five, 22, and 21 individuals, respectively. Evidence for the presence of *Euryapteryx* rests on identification of a single leg bone (Rawlence *et al*. 2011).

A suite of 12 accelerator mass spectrometry (AMS) radiocarbon ages for *Pachyornis* (Rawlence *et al*. 2011) augmented the single *Pachyornis* and two *Emeus* ages published earlier (Worthy & Holdaway 1996). The ages reported by Rawlence *et al*. (2011) were measured by the Australian National University Laboratory (Canberra) on five individuals of *Pachyornis* in three tranches of three, one of two, and a single age. Each of the tranches of three was measured on a single bone with different pretreatments, over – judging by the gaps in the ANU number series (ANU16xx; ANU49xx; ANU76xx) – three successive periods. The tranche of two was measured during the second and third (ANU49xx & ANU76xx) dating episodes and the single age was measured during the first (ANU16xx). The date numbers are reported here as cited in Rawlence *et al.* (2011): the current prefix for ANU AMS ages is SANU.

The term "pre-treatments" is taken here, as in Rawlence *et al.* (2011), to include the processes involved in graphitisation of each carbon sample in preparation for measurement in an accelerator. Others may restrict the term to the processes of extraction and purification of protein from the bone, but graphitisation or generation of CO_2 for insertion in the accelerator obviously also takes place before the measurement and can, as is discussed by Rawlence *et al*. (2011), introduce non-target carbon into the sample. Biochemical treatments were not uniform across the three tranches. While Rawlence *et al*. (2011) note that sample preparation for ANU1605-1610 performed at the University of Wollongong included an ultrafiltration stage, the protocol was changed for ANU4079-4937 and ANU7612-7625. For these "The 8 μm Eezi filter dialysis step was not included as this is not necessary to retrieve pure collagen (Higham *et al* 2004)". It is not clear from this whether or not the ANU treatment included ultrafiltration as the Eezi filter process was not mentioned separately for the ANU1605-1610 samples.

As part of another project, I recalibrated all the moa ages from Glencrieff, using the most recent Southern Hemisphere calibration curve, SHCal20 (Hogg *et al.* 2020), invoked in the OxCal 4.4 software (Bronk Ramsey 2009). The calibrated date distributions differed from those suggested by Rawlence *et al*. (2011). The differences are explored and assessed here. In addition, the presence of *Euryapteryx* in the early Holocene of North Canterbury as implied by the ages on the other two moa taxa is questioned: there are issues of identification by morphology and by consideration of the overall likelihood in terms of numbers of specimens per individual in the whole collection.

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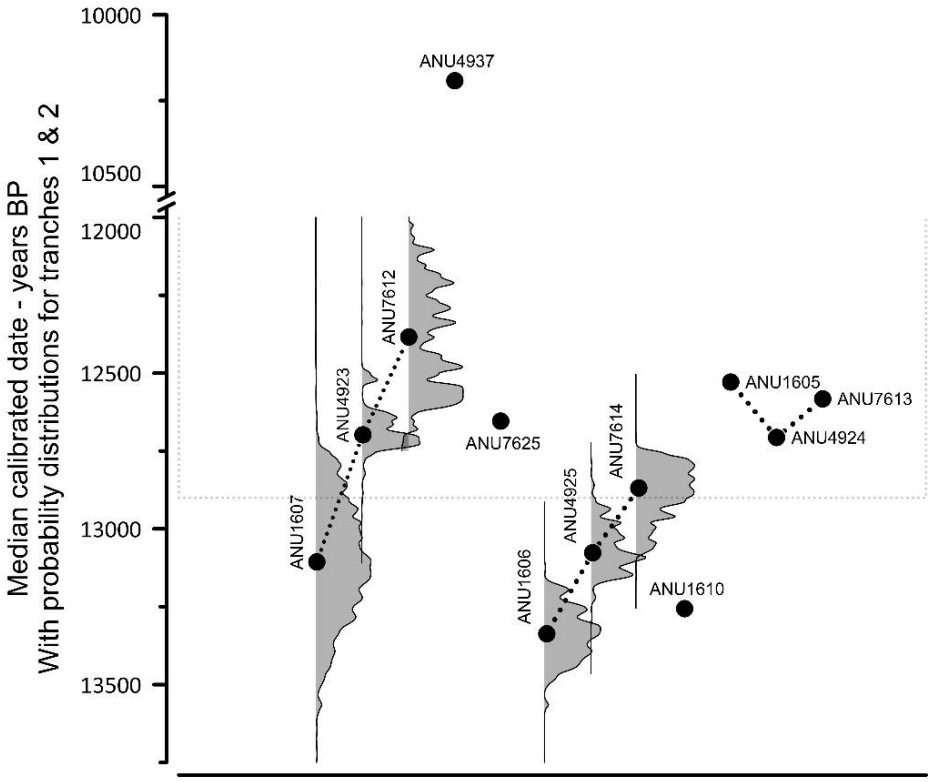

Figure 1. Median calibrated calendar dates of radiocarbon ages on *Pachyornis* moa individuals from the Glencrieff site, North Canterbury, South Island, New Zealand. Calibrated date probability distributions shown for ages in Tranches 1 and 2. Broken line, Younger Dryas period (ends *c.* 11,700 BP). Note break in y-axis.

There are trends towards younger ages in the series ANU1607, ANU4923, and ANU7612 on specimen S32670.9 (Museum of New Zealand Te Papa Tongarewa collection) and on ANU1616, ANU4925, and ANU7614 measured on S32670.3 (same collection) (Fig. 1). The single age (ANU1610) on specimen S32670.7 was, as with the other ages in the ANU16xx series, older. In contrast, the age (ANU4937) on specimen S32670.8 was, at a conventional radiocarbon age of 9070 ± 80 BP, much younger than any other, including ANU7625, which was within the range of the ANU76xx age series for S32670.9 and S32670.3 (Fig. 1). Ages in the third tranche of three, on specimen 32670.2, were all within the age range of the ANU76xx series on other samples (Fig. 1).

The trends to younger ages with measurement date and treatment in two of the three age series and the median dates for the others in each series mean that it was inappropriate for Rawlence *et al*. (2011) to statistically combine the *Pachyornis* ages. The only ages that can be used with confidence at present are those in the ANU76xx series. This agrees with Rawlence *et al*.'s (2011) statement that "The ages obtained for the bones using the UF3 method [i.e. the 76xx tranche] are the most reliable" in the first paragraph of their discussion. With this condition, the date span of occupation in the site area is *c*. 500 and not 1000 years. All ANU76xx series median dates and probability distributions lie in the first half of the Younger Dryas (Fig. 1), a return to glacial climate. The YD is not supposed to have affected New Zealand (Barrows *et al.* 2007; Kaplan *et al*. 2010) or Australia, but see Holdaway (2021).

The three other ages for Glencrieff moa were measured at the Rafter Radiocarbon Laboratory, GNS Science, Lower Hutt and published in 1996 (Worthy & Holdaway 1996). Two are on individuals of *Emeus* (NZA4018, NZA4079), and one on *Pachyornis* (NZA4162). The *Pachyornis* date (11898 ± 82 ^{14}C years BP; calibrated mean 13722 ± 115 SD) is older than any of the ages reported by Rawlence *et al*., including those questioned here (Fig. 2). This raises, of course, at least three questions: which of the ANU series should be retained; is there an issue with the NZA age; and was there a gap in the presence – or at least of the deposition – of *Pachyornis* in Glencrieff? These questions cannot be answered without further radiocarbon ages on both taxa, preferably from the area excavated in the 1990s.

It might be argued that the Rafter ages, which were measured on samples prepared by the ABA (acid, base, acid) protocol, are unreliable and that an additional stage of "ultrafiltration" (UF) is necessary to provide useable radiocarbon ages on bone. However, an interlaboratory comparison (Kuzmin *et al.* 2018) in which four leading radiocarbon laboratories dated samples from a single bone of an elk (*Alces alces*) (moose in North American terminology) from western Germany, of similar vintage to the moa in the Glencrieff site, failed to show evidence for systematic unreliability of ABA-processed samples with respect to those subjected to ultrafiltration (Fig. 2). The regions of highest probability for UF treatments were *c*. 150 years at most from the centres for ABA-treated samples. There is therefore no *prima facie* case for rejecting Rafter ABA-protocol radiocarbon ages on moa bone or indeed bone of any other vertebrate.

Hence, with the presently available ages on moa from the site, it is reasonable to posit that the bulk of the probability distributions of the calibrated dates for the two *Emeus* (which overlap almost entirely) sit at the "young" end of the *Pachyornis* distributions (Fig. 3). This raises at least the possibility that *Emeus* replaced *Pachyornis* in the area. I tested this by applying Sequence analysis in the OxCal4.4 software to the two radiocarbon age series, invoking the "Overlapping" option as replacement was unlikely to have been instantaneous.

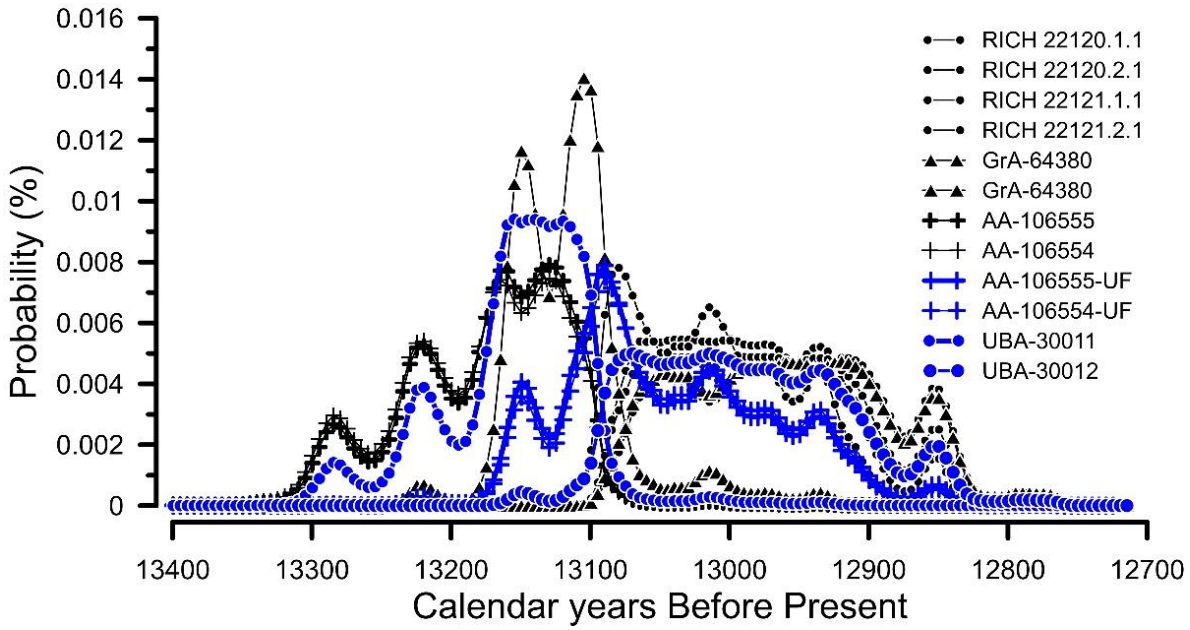

Figure 2. Calibrated calendar date probability distributions of ages generated in an interlaboratory comparison of organic chemistry pre-treatment protocols on a single bone of European elk (*Alces alces*) (American moose). Black, Acid-Base-Acid (ABA) treatments; Blue, ABA followed by ultrafiltration. Symbols, laboratories. RICH, Royal Institute for Cultural Heritage, Department of Laboratories, Belgium; GrA, Groningen; AA, Arizona; UBA, 14Chrono, Belfast. Data from Kuzmin *et al.* (2018).

The highest probability for a change was c. 12,500 BP (Fig. 3). Clearly there is a need for longer series radiocarbon ages on both taxa for this hypothesis of species replacement, and that of an association with a brief return to glacial climate, to be tested.

Rawlence *et al*. (2011) reported 22 individuals (830 bones) of *Pachyornis* and 21 individuals (873 bones) of *Emeus crassus* in the combined collections from the site. The 2007 excavation was of an area south of, and separate from, the 1996 excavation (Worthy & Holdaway 1996). This second excavation yielded four left and eight right tarsometatarsi of *Pachyornis* and three left and four right tarsometatarsi of *Emeus*. From the 2007 excavation they reported a single bone, a left tarsometatarsus, of *Euryapteryx*. Including the 118 bones representing 5 individuals of *Dinornis robustus*, 1822 bones of moa have been identified from Glencrieff: of these, only one has been attributed to *Euryapteryx*.

Given the high recovery rates for elements per individual in *Pachyornis* (37.7) and *Emeus* (41.6), the presence of only a single bone of *Euryapteryx* seems anomalous. It is not always straightforward to separate the limb bones of *Emeus* and *Euryapteryx* on their morphology. In 100 individuals identified as *Emeus* by morphology and morphometrics in collections from Bell Hill Vineyard, Pyramid Valley, and Rosslea, all within 10 km of Glencrieff, 18 were re-identified genetically as *Euryapteryx* (Allentoft *et al.* 2014).

The reverse must be possible. Could the Glencrieff left tarsometatarsus be the "missing" left tarsometatarsus

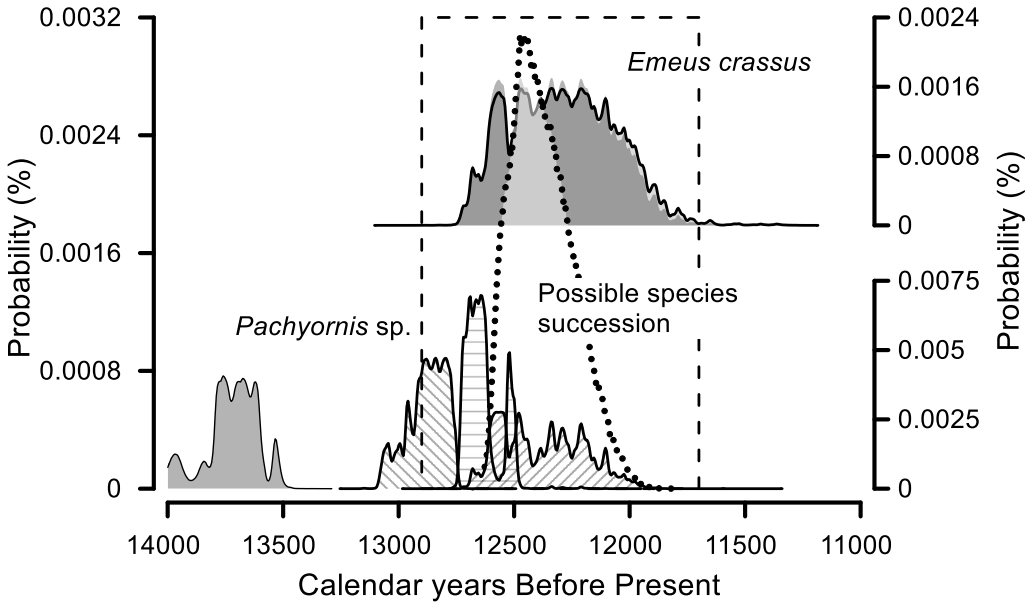

Figure 3. Calibrated date probability distributions for samples of *Emeus crassus* and *Pachyornis* sp. from Glencrieff, with probability distribution for date of possible species succession. Dashed box, Younger Dryas. NZA ages shaded.

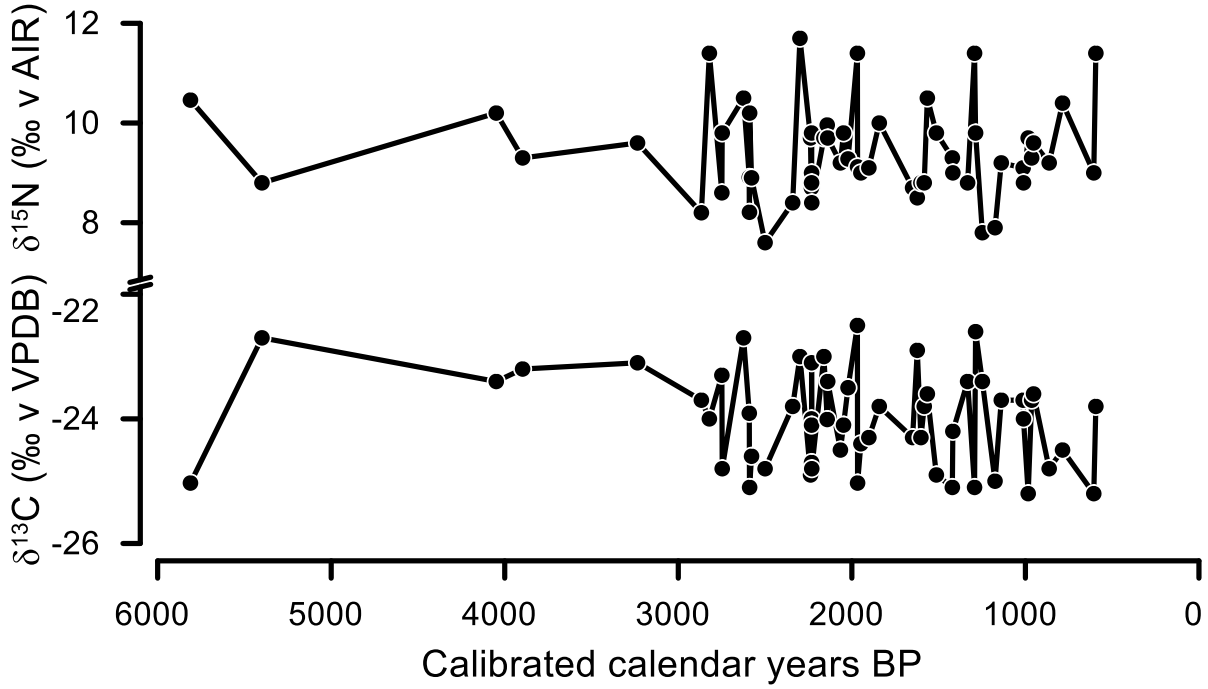

Figure 4. Median calibrated dates on *Euryapteryx* individuals from Pyramid Valley, Bell Hill Vineyard, and Rosslea sites, North Canterbury, South Island, New Zealand, arrayed against their carbon and nitrogen stable isotope ratios. The earliest two are from Rosslea, 1 km west of Bell Hill Vineyard, itself 5.8 km east of Pyramid Valley. The next oldest are two from Pyramid Valley, 1.5 km east of Glencrieff. Data from Allentoft *et al.* (2014) and Holdaway *et al.* (2014). Note break in y-axis.

of *Emeus*? If it is indeed referrable to *Emeus* – and this is testable by ancient DNA – then the first dated postglacial presence of *Euryapteryx* in North Canterbury is, at *c.* 5,800 years BP, the oldest *Euryapteryx* in the Rosslea deposit (Fig. 4) (Allentoft *et al.* 2012). Hence, on available radiocarbon ages, the oldest post-glacial *Euryapteryx* in the northern South Island are those from Irvine's Cave in Takaka Valley (Worthy & Holdaway 1994). That northern population was extirpated, apparently, by the return to glacial climate signalled by the renewed presence of *Pachyornis australis*, which preferred high altitude/glacial vegetation (Rawlence *et al*. 2012; Holdaway & Rowe 2020; Holdaway 2021).

An apparently earlier presence of *Euryapteryx* in North Canterbury was reported as its representing 33% of all moa individuals recovered from loess on Banks Peninsula (Worthy 1993). Only one moa, a *Pachyornis* from "base of 10 m thick loess deposit that overlay volcanic rock", has been radiocarbon dated. Its conventional radiocarbon age of 27,700 ± 1,400 years BP (NZ5382) corresponds, referenced to the SHCal20 calibration curve, to a calendar date of 32,428 ± 1614 years BP. Most if not all of the *Euryapteryx* individuals had been recovered from much shallower (0.75 – 3 m) depths, in loess thought to be less than 25,000 years old (Worthy 1993). The Port Hills loess is easily eroded (Trangmar & Cutler 1983); it is possible that several metres have been lost since Polynesian fires removed the forest several centuries ago.

Airfall tephra from the Oruanui eruption of Taupō volcano 25,400 years ago was 100 mm deep at Christchurch (Vandergoes *et al*. 2013). That depth of tephra causes significant damage to vegetation and fauna (Oppenheimer 2011) and could well have eliminated moa populations. More radiocarbon ages will be required before the presence of *Euryapteryx* after the eruption and before 6,000 BP can be tested. If any DNA has been preserved in the usually poorly preserved bones from the loess, analysis would allow a test of the hypothesis presented here of a recent, post-glacial, colonisation.

Keywords radiocarbon ages, radiocarbon sample treatment, *Euryapteryx*, *Emeus*, climate

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SHORT NOTE

Corrected publication dates for *Notornis* to Volume 72, 2025

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Notornis is the scientific journal of the Ornithological Society of New Zealand, and has been published quarterly since July 1950 (Volume 4, Part 1). The numbering sequence continued on from *New Zealand Bird Notes* (originally *N.Z. Bird Notes*), which was first published in January 1943 (Heather 1990). Each issue has the target publication date (henceforth 'target date') displayed on the front cover. Target date months were inconsistent initially, until January, April, July, and October were settled on in 1947; these were changed to March, June, September, and December in 1960.

Until 1994, the target date was often (but not always) the only date shown on or in each issue. Individual articles have displayed the dates that they were received and accepted (inconsistently initially) since 1995. In addition to reception and acceptance dates of manuscripts, the publication date for each issue was routinely displayed on the inside front cover or on front or end pages from 1946 until April 1955, and again since 2000. As there has been no centralised record of when each issue was actually published, the latest internal date (henceforth 'evident date') within each issue is here regarded as a proxy for the actual publication date.

Notornis issues were published later than their target date on at least 24 occasions between 1960 and 2025 (Table 1). No issues are known to have been published before their target date. On 11 occasions, an issue was published in the year following the year specified in the target date; the affected issues are highlighted in Table 1. In the most extreme case (Volume 54, Part 4), publication was delayed by a full 12 months, with the four adjacent issues each delayed by 9–11 months.

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Table 1. *Notornis* issues known to have been published after their target publication date. Issues that were published in the year following their target year are shown in bold and shaded.

Volume, Part	Target date	Evident date	Delay (months)
9,1	Jun 1960	Jul 1960	1
45, 3	Sep 1998	Oct 1998	1
54, 2	**Jun 2007**	**May 2008**	**11**
54, 3	**Sep 2007**	**Jul 2008**	**10**
54, 4	**Dec 2007**	**Dec 2008**	**12**
55, 1	Mar 2008	Dec 2008	9
55, 2	**Jun 2008**	**Mar 2009**	**9**
55, 3	**Sep 2008**	**Mar 2009**	**6**
55, 4	**Dec 2008**	**Jul 2009**	**7**
56, 1	Mar 2009	Oct 2009	7
56, 2	Jun 2009	Nov 2009	5
56, 3	**Sep 2009**	**Jan 2010**	**4**
56, 4	**Dec 2009**	**Mar 2010**	**3**
57, 1	Mar 2010	Jun 2010	3
57, 2	Jun 2010	Oct 2010	4
57, 3	Sep 2010	Dec 2010	3
57, 4	**Dec 2010**	**Apr 2011**	**4**
58, 1	Mar 2011	Aug 2011	5
58, 2	Jun 2011	Oct 2011	4
58, 3&4	**Sep & Dec 2011**	**Feb 2012**	**2**
71, 1	Mar 2024	May 2024	2
71, 2	Jun 2024	Aug 2024	2
71, 3	Sep 2024	Dec 2024	3
71, 4	**Dec 2024**	**Jan 2025**	**1**

The publication year for the 120 articles contained in these 11 'year-delayed' issues conflicts with the date given in the recommended citations provided at the time of publication (for the 50 full papers) and the target date on the cover of the issue that they appeared in. As a result, these articles are routinely cited with incorrect publication dates. For example, eight of the articles are cited with incorrect publication years in the current *Checklist of the birds of New Zealand* (Checklist Committee 2024). Corrected publication dates for the 120 affected articles are provided in the Appendix, and have been updated in the Birds New Zealand online Publications Archive (https://www.birdsnz.org.nz/publications/). Users of the online archive should note that the landing page for each affected article now displays the correct publication year; however, the pdfs that the landing pages link to remain as they were originally published, with the (incorrect) target year in the recommended citation for each full paper.

A particularly important impact of an incorrect publication date is where it effects the apparent publication date of a new scientific name. This happened on a single occasion in the 11 'year-delayed' *Notornis* issues, with the paper describing *Coenocorypha aucklandica perseverance* Miskelly & Baker appearing in Volume 56 Part 3 (target date = September 2009, evident date = January 2010). The correct publication date for the taxon name was clarified in Volume 57 Part 1 (Miskelly & Baker 2010a & b).

I thank Brian Gill and Alan Tennyson for their helpful comments and suggestions.

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Keywords citation, delayed publication, priority

Appendix

Notornis articles that were originally published with incorrect year dates. Corrected publication dates are shown here. All were published between 2008 and 2025.

Adler, G.H.; Lalogafu'afu'a, A.; Seamon, J.O.; West, R.J.; Fa'aumu, S.; Atkinson, C.T. 2011. Persistence of the spotless crake (*Porzana tabuensis*) on Ta'u, American Samoa. *Notornis 57*(4): 216–217, doi.org/10.63172/069653yvhjhl

Armitage, I. 2008. Wrybill (*Anarhynchus frontalis*) at the Manawatu River estuary, North Island, New Zealand. *Notornis 54*(2): 118–119, doi.org/10.63172/357596svbpjq

Armitage, I. 2008. Further evidence for the natural re-establishment of the pipit (*Anthus novaeseelandiae aucklandicus*) on Campbell Island, New Zealand. *Notornis 54*(4): 226–228, doi.org/10.63172/991600mtvrug

Ayala, L. 2008. Records of juvenile northern giant petrels (*Macronectes halli*) in Peruvian seas. *Notornis 54*(4): 234–236, doi.org/10.63172/206412aerfat

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Barnett, C. 2012. Changes in the observed bird abundance in a modified forest at Kowhai Bush, Kaikoura. *Notornis 58*(3&4): 131–138, doi.org/10.63172//436131embopv

Battley, P.F.; Moore, P.J.; Moore, S.J. 2009. Southern royal albatross (*Diomedea epomophora*) dies from ingesting a porcupine fish. *Notornis 55*(4): 207–208, doi.org/10.63172/731841jrcvqx

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Beauchamp, A.J.; Parrish, G.R. 2008. Wader (Charadriiformes) and royal spoonbill (*Platalea regia*) use of roosts in Whangarei Harbour and at Ruakaka estuary, Northland, 1973–2000. *Notornis 54*(2): 83–91, doi.org/10.63172/401269jnstxs

Bell, B.D. 2009. Tui (*Prosthemadera novaeseelandiae*) increase at Seatoun, Miramar Peninsula, Wellington, New Zealand during 1998–2006. *Notornis 55*(2): 104–106, doi.org/10.63172/043519nvbcaw

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Briskie, J.V. 2012. The effect of earthquake aftershocks

on the dawn chorus of an Eurasian blackbird (*Turdus merula*). *Notornis 58*(3&4): 175–176, doi.org/10.63172//211882kktzor

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