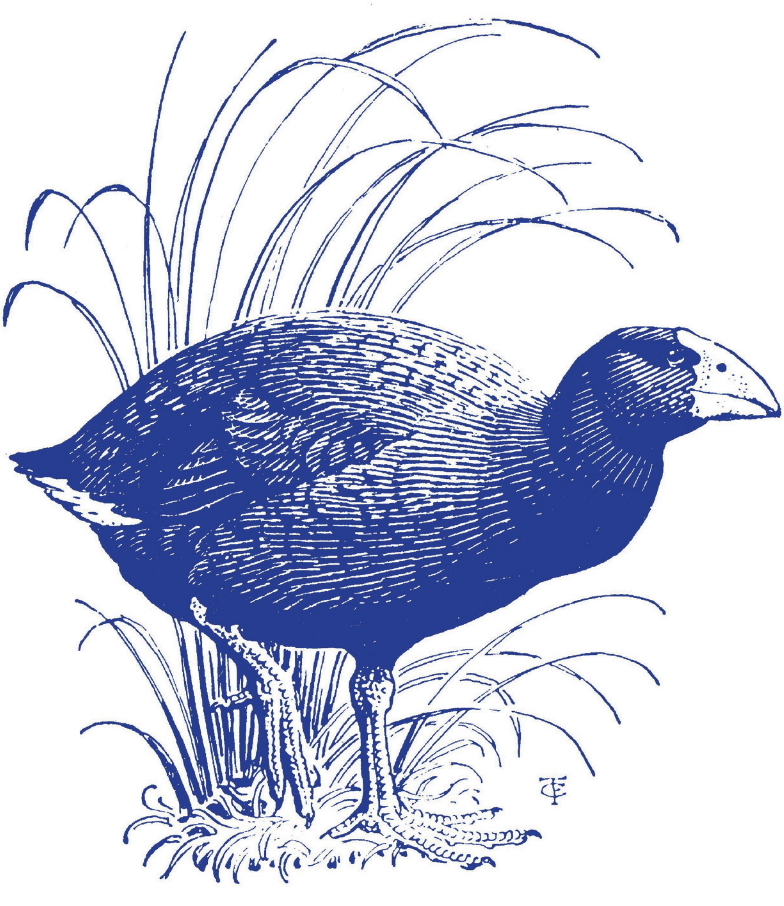
NOTORNIS

Ornithology of the Southern Pacific



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NOTORNIS

Scope *Notornis* is published quarterly by the Ornithological Society of New Zealand Inc. The journal publishes original papers and short notes on all aspects of field or laboratory ornithology, and reviews of ornithological books and literature, student research, and reports of specialist ornithological events. *Notornis* concentrates on the birds of the ocean and lands of the Southern Pacific, with special emphasis on the New Zealand region. It seeks to serve professional, amateur and student ornithologists alike, and to foster the study, knowledge and enjoyment of birds.

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- To foster and support the wider knowledge and enjoyment of birds generally.
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- To produce a journal and any other publication containing matters of ornithological interest.
- To effect co-operation and exchange of information with other organisations having similar aims and objects.
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- To maintain a library of ornithological literature for the use of members and to promote a wider knowledge of birds.
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Effectiveness and efficiency of avian species detection: a comparison between field observers and automatic recording devices

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Abstract: The monitoring of animal populations is essential for reporting on the state of the environment, with birds often used as indicators of ecosystem health. Traditionally, bird monitoring has been done by field observers; however, there has been recent interest in use of automatic recording devices (ARDs) as an alternative. A monitoring programme managed by the New Zealand Department of Conservation (DOC), used observers and ARDs concurrently for three survey seasons, providing the opportunity to compare results in terms of effectiveness and efficiency. The difference in species-richness estimates from the two methods was small, with the observer method detecting slightly higher numbers of species in all habitat types. Detection probabilities for individual species, derived from occupancy analysis, were similar between methods, with a few exceptions: bellbird (*Anthornis melanura*), brown creeper (*Mohoua novaeseelandiae*), tūī (*Prosthemadera novaeseelandiae*), North/South Island robin (*Petroica longipes/australis*), and rifleman (*Acanthisitta chloris*). Bellbird and rifleman had a higher probability of being detected by ARDs, whilst the remainder were more likely to be detected by observers. Differences in detection probability may be due to identification confusion in the case of bellbird and tūī, and observer ability to detect and identify birds visually for brown creeper and North/South Island robin. The relationship between indices of abundance from the observer and ARD methods varied between species and habitat types. These inconsistencies suggested that the ARD results did not correlate closely with observed abundance, which may limit the ARD method to provision of confirmed presence data. Observer counts proved to be more time-efficient given present levels of processing technology, mainly due to the longer processing time required for ARD recordings. However higher numbers of people were required for observer counts, which may be problematic when there is a shortage of appropriately skilled observers at the required time of year.

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Key words: bird monitoring, detection probability, species-richness, acoustic recording, indices of abundance

INTRODUCTION

There are strong social, economic, and ethical drivers, both national and international, behind the development of biodiversity monitoring systems which enable measurement of biodiversity trends and the impacts of management for reporting on the state of the environment (Allen *et al*. 2003; Lee *et al*. 2005). The National Biodiversity Monitoring and Reporting System, administered by the New

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Zealand Department of Conservation (DOC), was recently developed and implemented to provide a multi-tiered monitoring framework to enable reporting on national trends in biodiversity (referred to as "Tier 1"), effectiveness and impacts of management ("Tier 2"), and research/long-term monitoring objectives ("Tier 3"; Allen *et al*. 2009). Monitoring populations of common and widespread bird species is one of the key measures of the programme, as birds can be useful environmental indicators (Bibby *et al*. 2000). This is particularly the case when species diversity, distribution and abundance, species-habitat relationships, and responses to environmental change or management can be determined (Simons *et al*. 2007).

Implementing a national monitoring programme requires considerable resources, especially the mobilisation of appropriately-skilled staff and sufficient finances, both of which may be limited. The challenge is, therefore, to maximise data collection efficiency wherever possible, without compromising data quality. Use of novel technologies has the potential to reduce time and staffing requirements and improve efficiency. Recent technological developments have produced tools with the potential to augment or even replace the more traditional field observer approaches to ecological monitoring (e.g. Xie *et al*. 2008; Nagendra *et al*. 2013). Use of automatic recording devices (ARDs) has increased dramatically in recent years (Brandes 2008; Steer 2010; Frick 2013; Cook & Hartley 2018), with ever-more elaborate systems enabling, for example, monitoring of complete habitats via use of sensor networks (Szewczyk *et al*. 2004).

In bird monitoring, ARDs are gaining popularity as an increasing range of devices has become available (Brandes 2008; Frick 2013). Upon initiation of the Tier 1 Monitoring Programme, DOC recognised an opportunity to test the relative effectiveness for species detection and efficiency between field observer and ARD-based bird monitoring techniques, and to inform decisions on long-term choice of survey method.

Several previous studies have compared species detection abilities of observers and ARDs. Haselmeyer & Quinn (2000) found that the two methods were overall equally effective at detecting species-richness, although ARDs detected more species when richness was high and observers were more effective for rarely-heard species. Likewise, Sedlácek *et al*. (2015) found that the ARD and observer methods provided similar estimates for species-richness, abundance, and community composition. Wimmer *et al*. (2013) showed that ARDs were able to detect a higher number of species than observers, whereas in some other studies the observer method was more effective (Hutto & Stutzman 2009; Leach *et al*. 2016; Stewart & Hasenbank 2018). Holmes *et al*. (2014) found ARDs to be the most time-efficient method; however, Hutto & Stutzman (2009) found ARDs to be less time-efficient than observers. All these studies focused on a limited number of sites in their respective countries and were not part of a national monitoring programme. To our knowledge, there have been three studies to date which compared observers and ARDs within New Zealand (Digby *et al*. 2013; Stewart & Hasenbank 2018; Bombaci & Pejchar 2019). However, the comparisons were for single species and/or at only one or few geographic locations. This study compared data collected simultaneously by field observers and ARDs for a national monitoring programme on Public Conservation Lands (PCL), and simultaneously assessed the effectiveness of the two methods in terms of species detection, estimation of abundance, and efficient use of resources.

MATERIALS AND METHODS

Field sampling protocols

The Tier 1 Monitoring Programme was initiated in 2011 and is based upon a randomly-placed 8 km grid, covering mainland New Zealand and offshore islands. A total of 1,354 randomly-selected grid intersection points within Public Conservation Lands (which extend to one third of New Zealand's land area; DOC 2015), were used to determine sampling locations. Locations are sampled on a five-year cycle, meaning approximately 270 are sampled each survey season (October to March inclusive).

Sampling locations were established and measured as per the methods described in MacLeod *et al*. (2012) and Mortimer & Greene (2017). At each sampling location there were 5 bird count stations, spaced approximately 200 m apart (Fig. 1). A single ARD was deployed at each bird count station, set to record concurrently with the field observer bird count.

ARDs were set to record continuously for one nocturnal time-period (2000 h – 0600 h; New Zealand daylight saving time, GMT + 13 hrs) and one diurnal time-period (0700 h – 1300 h). The ARDs were developed and designed by DOC, each incorporating 4 x wm61a electrets microphones in parallel with a foam 'pop filter' and custom-made low noise pre-amplifier with a DSP anti-aliasing filter. Recordings were stored on Secure Digital (SD) memory card as a series of compressed 32 kHz, 16-bit audio files in waveform audio format (.WAV file extension), with a bit-rate of 512 kbps, each approximately 15 minutes in length.

A 5-minute bird count (an index of relative abundance, not adjusted for detection probability) was completed at each station, using standardised

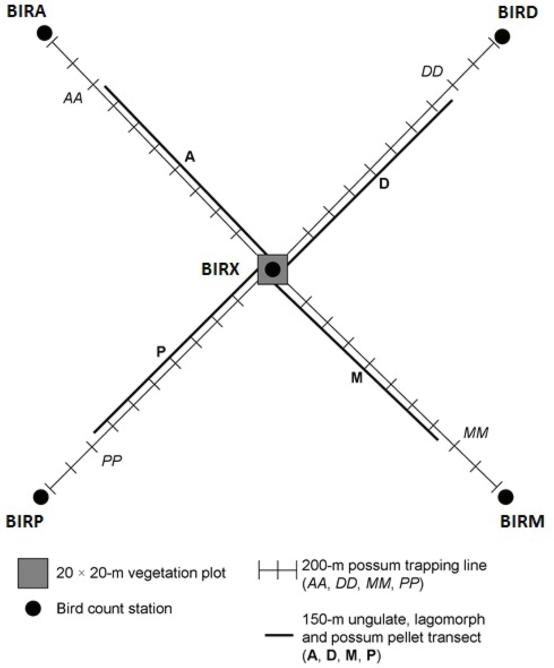

Figure 1. Tier 1 Monitoring Programme sampling location design, showing locations of bird count stations (BIRA, BIRD, BIRM, BIRP, and BIRX).

methods adapted from Dawson and Bull (1975). Although all birds seen or heard were noted, whether these observations were aural or visual was not recorded. To enable comparison between observer counts and processed ARD recordings, the precise start of each count was identified by a field observer clearly vocalising the start of the 5-minute bird count, to effectively synchronise both methods. Counts began not less than 1 hour after official sunrise and were completed by 1300 h. If time allowed, two 5-minute bird counts were completed at each station, with a minimum of 60 minutes between counts at the same station. A single 5-minute count period per station was used in the comparison between ARD and observer methods (usually the first period, unless in the event of adverse weather or ARD failure, in which case the second period was used). In addition to number and species of birds, observers recorded a range of environmental details as categorical covariates (i.e. temperature, sun, precipitation, wind, and noise; see Appendix 1). In practice, many sampling locations had fewer than five stations due to abandonment on safety grounds or excessive environmental noise (e.g. rivers, etc.). In addition, some recordings were excluded from processing, due to excessive noise from wind, rain, or other environmental sources (e.g. invertebrates). In cases where data for a 5-minute period were excluded for one method, the corresponding data for the other method in the same time period were also excluded (i.e. all 5-minute periods included in the analysis had data from the field observer and ARD). In summary, 47 sampling locations had 5 stations for which observations were recorded using both methods, 70 sampling locations had 4 stations, 92 sampling locations had 3 stations, 131 sampling locations had 2 stations, and 58 sampling locations had 1 station. During the first three seasons of the Tier 1 Monitoring Programme (2011–12, 2012–13, and 2013–14), diurnal ARD recordings were processed from 65, 88, and 245 sampling locations respectively, resulting in a total of 1,112 5-minute periods from 398 sampling locations with a field observer 5-minute bird count and a corresponding processed ARD 5-minute period (Fig. 2). The first two survey seasons had a reduced number of sampling locations surveyed due to phased implementation of the programme.

Processing of ARD recordings

A single 5-minute period was processed for each

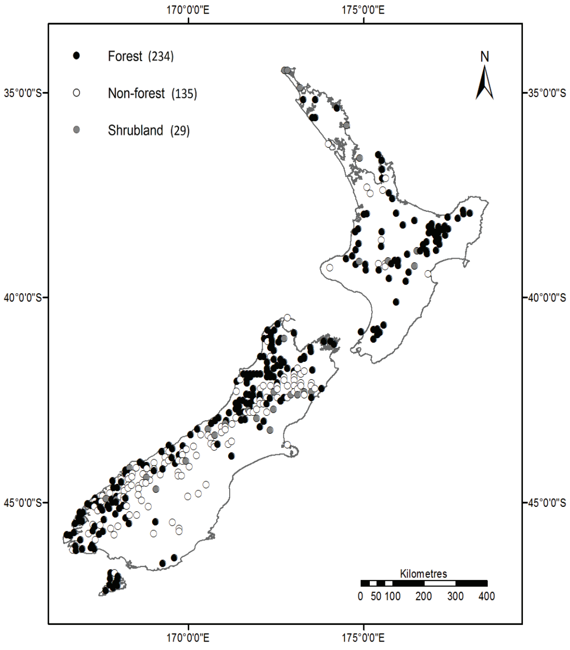

Figure 2. Tier 1 sampling locations across New Zealand at which observer counts were completed and corresponding ARD recordings processed, with habitat type (figures in brackets show number of sampling locations per habitat).

bird count station at each sampling location. ARD recordings were processed manually by experienced ornithologists, using the custom-designed Freebird call analysis software, version 1.1.6.4 (Freebird 2013). This generated sonograms from the recordings and allowed audio playback for species identification. Identified calls were tagged by drawing a box around the appropriate part of the sonogram and labelling it with the species name from a drop-down list. The processor identified and tagged presence of each species within 10-second blocks (30 blocks per 5-minute period). A species would not be tagged more than once in the same 10-second block, irrespective of the number of calls. If a single call spanned multiple 10-second blocks, then the species was tagged as present in each block. To limit effects of fatigue, processors were advised not to spend more than 25 hours per week on processing. Upon completion of processing a 5-minute period, the results were exported in comma separated values (CSV) format and later aggregated for analysis.

Data analyses

Each sampling location was assigned to the broad habitat type corresponding to assessment of the 20 x 20 m vegetation survey plot (see Fig. 1): forest (234 sampling locations), non-forest (135 sampling locations), or shrubland (29 sampling locations). This classification was used to divide the sampling locations by habitat for graphical presentation of results. For statistical analyses, each bird count station was assigned a habitat type (forest, non-forest, or shrubland), using Land Cover Database (LCDB) classifications (Thompson *et al*. 2003): see Appendix 2. For occupancy analysis this allowed the inclusion of habitat as a survey covariate in the estimation of detection probabilities for each survey method. Analyses were performed using the R statistical software (version 3.1.2; R Core Team 2014) except occupancy estimates, which used program PRESENCE (version 10.5; Hines 2006). Comparisons between observer-based counts and ARD recordings were made using a range of metrics, namely species-richness, detection probability, and indices of abundance.

Relative effectiveness at detecting species-richness was assessed by summing the total number of species recorded for each 5-minute period, for each survey method, then plotting the observer species-richness against ARD species-richness, with loess curves to model relationships. The data were then modelled using a generalised linear mixed model (GLMM) with a Poisson distribution, with observer species-richness as the response variable and ARD species-richness, habitat, wind, and noise as explanatory variables. Sampling location was included as a random effect, to account for the lack of independence of 5-minute count periods from the same sampling locations. Prior to modelling, ARD species-richness was normalized by subtracting the mean, and then dividing by the standard deviation (to produce a Z value). There were four candidate models, which included various combinations of explanatory variables (Table 1). The models were fitted with a unique intercept and slope (against the ARD species-richness) for each habitat type and the model with the lowest Akaike Information Criterion (AIC; Burnham & Anderson 2002) value was selected. The coefficient estimates indicate, on a logarithmic scale, the effect size of the explanatory variables on the response variable. Diagnostic plots were used to test validity of the model, following Zuur *et al*. (2013), and the data were tested for over-dispersion.

Occupancy analysis (MacKenzie *et al*. 2018) was carried out for the top 16 species (those recorded at the highest number of sampling locations). For each 5-minute count period, each species was assigned a 1 or 0 to indicate whether or not it was detected by each method. This resulted in four possible 'detection histories': 00 (not detected by either method); 10 (detected by the observer method but not the ARD method); 01 (not detected by the observer method but detected by the ARD method); and 11 (detected by both methods). From this, we were able to calculate the detection probability for each species in a 5-minute count period. For species that occur on only the North or only the South Island, data were included only for sampling locations from the relevant island. A single-season multi-method analysis approach was used, which accounts for the lack of independence between detection methods for each sampling occasion (Nichols *et al*. 2008). Eight biologically plausible *a priori* candidate models were considered, which included various combinations of what were considered to be the most important survey covariates, i.e. habitat, wind, and noise (Table 2; Appendix 1; Robbins 1981; Pacifici *et al*. 2008). All models assumed psi (Ψ; the probability that a site is occupied by the species) and theta (Θ; the probability that individuals are available for detection using a method, given presence) were constant, and p (the probability of detecting the species using a method in a survey) remained constant through time. Since we were only interested in p, there was no reason to allow psi or theta to vary by inclusion of covariates. Model fit was assessed using AIC (Burnham & Anderson 2002).

To compare our ability to measure changes in abundance, an index of relative abundance was created for each method, again only for the top 16 species. For the observer counts, this was simply the raw count of individuals of a species recorded

Table 1. Candidate models for GLMM analysis of species-richness estimates from the observer and ARD methods. OBS = observer species-richness; ARD = ARD species-richness; hab = habitat type (forest, non-forest, shrubland); w = wind (0–3); n = noise (0–2); sl = sampling location (included as a random effect). The '/' indicates that each model was fitted with a unique intercept and slope (against the ARD species-richness) for each habitat type.

Model	Model definition	No. of fixed effects
SR1	OBS ~ hab/ARD + w + n + (sl)	11
SR2	OBS ~ hab/ARD + w + (sl)	9
SR3	OBS ~ hab/ARD + n + (sl)	7
SR4	OBS ~ hab/ARD + (sl)	6

Table 2. *A priori* candidate models for individual species detection. Ψ = psi (the probability that a site is occupied by the species); Θ = theta (the probability that individuals are available for detection using a method, given presence); *p* = probability of detection; h = habitat type (forest, non-forest, shrubland); m = method (observer, ARD); w = wind (0–3); n = noise (0–2); K = the number of parameters in the model.

Model	Model definition	K	Model	Model definition	K
SD1	Ψ(.), Θ(.), *p*(m)	4	SD5	Ψ(.), Θ(.), *p*(m+w+n)	11
SD2	Ψ(.), Θ(.), *p*(m+h)	7	SD6	Ψ(.), Θ(.), *p*(m+h+w)	11
SD3	Ψ(.), Θ(.), *p*(m+w)	8	SD7	Ψ(.), Θ(.), *p*(m+h+n)	10
SD4	Ψ(.), Θ(.), *p*(m+n)	7	SD8	Ψ(.), Θ(.), *p*(m+h+w+n)	14

during each 5-minute bird count. For ARDs, the index was a count of the number of 10-second blocks in which a species was recorded for each 5-minute period, which was essentially an index of how frequently a bird species vocalised. This was named the 'acoustic prevalence index' (API), a term used by Cook & Hartley (2018) and calculated in a similar manner. The aim was to carry out an exploratory analysis of relationships between the observer index and API, identifying any that were consistent and predictable. Indices from the two methods were plotted against each other, with loess curves to model relationships for each habitat. Indices from the two methods were then compared for each species in each habitat type using GLMMs with a Poisson distribution. Prior to modelling, the API values were normalized by subtracting the mean, and then dividing by the standard deviation (to produce Z values). The models were specified using the same method as for species-richness analysis, but with observer index as the response variable and API as an explanatory variable.

A comparison of method efficiency was based upon estimates of mean time spent per sampling location for each method, effectively a proxy for cost. Detailed information was not available for all sampling locations. However, estimates could be calculated from observer field diaries and notes from ARD processing and data entry personnel. The ARD processing time estimates included time for processing of files (manual identification of bird calls) and data/file management. Travel time to and from the sampling location was excluded, as this would be identical regardless of which method was employed. The number of skilled individuals employed and number of 5-minute counts completed/5-minute ARD periods processed per person were also compared between methods, to provide insight into staff resource requirements.

RESULTS

Detection of species-richness

The number of species detected varied considerably between 5-minute periods for both methods (Fig. 3). From a total of 398 sampling locations, there were 93 where both methods detected no species. Interestingly, there were 57 sampling locations at which the observer method detected at least one species and the ARD method detected no species (mostly in non-forest habitats). Conversely, at three sampling locations the ARD method detected at least one species whilst the observer method detected none (all non-forest). Mean species-richness per 5-minute period was comparable for forest (observer = 5.03, 95% CI [4.88, 5.18]; ARD = 5.10, 95% CI [4.93, 5.28]) and shrubland (observer = 5.34, 95% CI [4.83, 5.85]; ARD = 4.80, 95% CI [4.22, 5.39]), with mean species-richness for non-forest being somewhat lower (observer = 2.77, 95% CI [2.55, 2.99]; ARD = 2.21, 95% CI [2.01, 2.41]). The loess model curves indicated a linear positive relationship between indices from the two methods, in all three habitat types (Fig. 3). There were two competing candidate GLMM models: SR2 and SR4 (Table 1), which achieved very similar delta AIC values (SR2 = 0, SR4 = 0.263). Model selection suggested that wind could be included as an explanatory variable; however, the effects of wind were small (Table 3). The existing data did not support the inclusion of noise into the model. The forest habitat type had the largest effect on species-richness, closely followed by shrubland (i.e. species-richness was generally highest in these habitat types; Table 3). ARD species-richness had an effect on observer species-richness, which means that for each increase in ARD species-richness, there was a slightly larger increase in mean observer species-richness. The effect of ARD species-richness was largest in non-forest (Table 3). Diagnostic plots did not indicate any problems with the model and the data were not over-dispersed.

A species accumulation curve (Southwood & Henderson 2000) was produced to compare the mean cumulative number of species detected with each successive bird count station surveyed, for both methods (Fig. 4). Significantly higher numbers of species were detected with increasing numbers of stations surveyed ($F(4, 2218) = 68.116$, $p < 0.001$). However, the results showed no significant difference in number of species detected by the two methods ($F(1, 2218) = 0.017$, $p = 0.897$).

Detection of individual species

Occupancy analysis for individual species revealed that habitat was an important factor influencing detection probability for most species. Wind and/or noise were important for all but three species (Table 4).

Values for p (the probability of detecting the species using a method in a survey), where wind

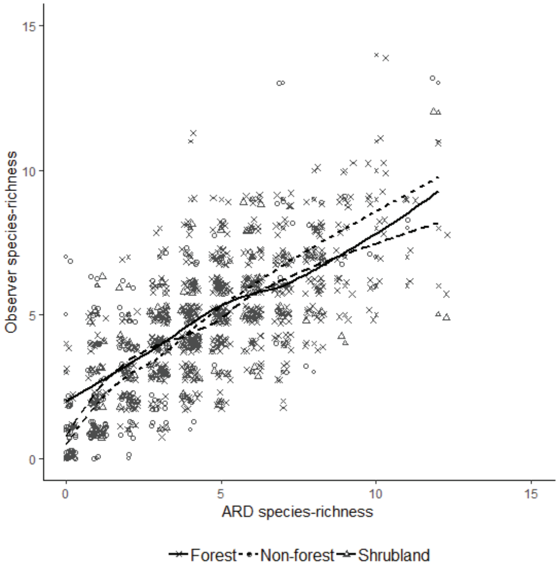

Figure 3. Comparison of species-richness detection per 5-minute period, for the observer and ARD methods. Loess curves show the relationship between indices from the two methods for each habitat type. Individual data points have been displayed using jittering to make those with the same values visible.

Table 3. Results of GLMM analysis (model SR2) to test for relationships between species-richness estimates from the observer method (response variable) and ARD method, wind and habitat type (explanatory variables). ARD species-richness values were normalized by subtracting the mean, and then dividing by the standard deviation. The estimate for forest is not shown as this was the reference habitat type to which non-forest and shrubland were compared. The '/' indicates that the model was fitted with a unique intercept and slope (against the ARD species-richness) for that habitat type.

Variable	Estimate	Standard error	p value
(Intercept)	1.511	0.024	<0.001
Non-forest	-0.398	0.044	<0.001
Shrubland	-0.080	0.056	0.149
Wind 1	-0.068	0.040	0.094
Wind 2	-0.068	0.065	0.029
Wind 3	-0.178	0.096	0.064
Forest/ARD	0.285	0.021	<0.001
Non-forest/ARD	0.501	0.026	<0.001
Shrubland/ARD	0.339	0.049	<0.001

and noise variables, if included in the selected model for that species, were both equal to zero, were compared (Fig. 5; for effects of other wind and noise values see Appendix 3). Where habitat was included in the model, probability of detection was generally highest in forest or shrubland habitats and lowest in non-forest. However, common redpoll (*Carduelis flammea*) detection probability was higher in non-forest and shrubland, whilst chaffinch (*Fringilla coelebs*) detection probabilities were similar across all three habitat types. Habitat was not included in the selected models for brown creeper, New Zealand fantail (*Rhipidura fuliginosa*), song thrush (*Turdus philomelos*), and whitehead (*Mohoua albicilla*). Probability of detection for individual species was similar between methods with the exceptions of (in all habitat types) brown creeper, and (in forest only) North/South Island robin (*Petroica longipes/australis*), bellbird (*Anthornis melanura*), and to a lesser extent tūī (*Prosthemadera novaeseelandiae*) and rifleman (*Acanthisitta chloris*). Bellbird and rifleman had a higher probability of being detected by ARDs, whilst the remainder were more likely to be detected by observers.

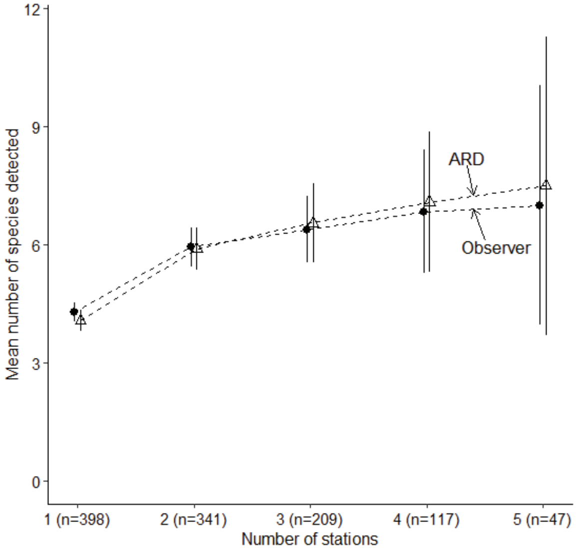

Figure 4. Mean cumulative number of species detected (±95% confidence intervals) by observers and ARDs with each successive bird count station surveyed/processed.

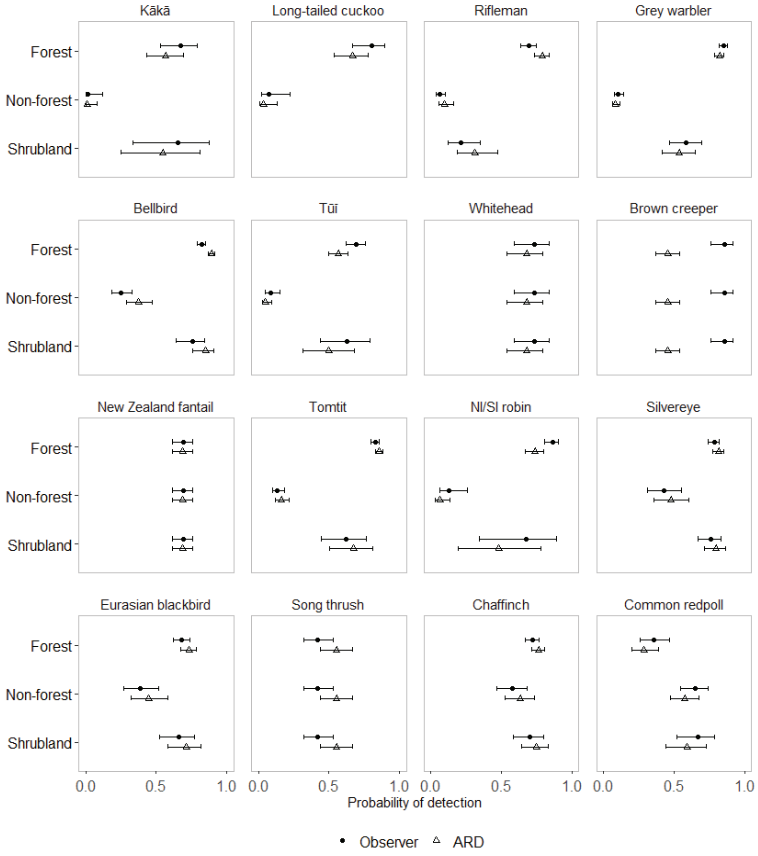

Figure 5. Probability of species detection (±95% confidence intervals), estimated using a single-season multi-method occupancy model (MacKenzie *et al.* 2006), for the observer and ARD survey methods within each habitat type.

Table 4. Occupancy analysis model selected for each species (Ψ = psi; Θ = theta; p = probability of detection; h = habitat type (forest, non-forest, shrubland); m = method (observer, ARD); w = wind (0–3); n = noise (0–2). Odds ratios provide an indication of which method was more effective at detection (1 = both methods equally effective; <1 = observer method more effective; >1 = ARD method more effective).

Species	Sampling locations	Model	Odds ratio
Kākā (*Nestor meridionalis*)	398	Ψ(.), Θ (.),p(m+h+n)	0.637
Long-tailed cuckoo (*Eudynamys taitensis*)	398	Ψ(.), Θ (.),p(m+h)	0.492
Rifleman (*Acanthisitta chloris*)	398	Ψ(.), Θ (.),p(m+h+w)	1.670
Grey warbler (*Gerygone igata*)	398	Ψ(.), Θ (.),p(m+h+w)	0.819
Bellbird (*Anthornis melanura*)	398	Ψ(.), Θ (.),p(m+h+w+n)	1.820
Tūī (*Prosthemadera novaeseelandiae*)	398	Ψ(.), Θ (.),p(m+h+n)	0.585
Whitehead (*Mohoua albicilla*)	93	Ψ(.), Θ (.),p(m+n)	0.778
Brown creeper (*Mohoua novaeseelandiae*)	305	Ψ(.), Θ (.),p(m+w)	0.140
New Zealand fantail (*Rhipidura fuliginosa*)	398	Ψ(.), Θ (.),p(m+w)	0.981
Tomtit (*Petroica macrocephala*)	398	Ψ(.), Θ (.),p(m+h+w+n)	1.268
North/South Island robin (*Petroica longipes/australis*)	398	Ψ(.), Θ (.),p(m+h+w)	0.446
Silvereye (*Zosterops lateralis*)	398	Ψ(.), Θ (.),p(m+h+n)	1.227
Eurasian blackbird (*Turdus merula*)	398	Ψ(.), Θ (.),p(m+h+w+n)	1.297
Song thrush (*Turdus philomelos*)	398	Ψ(.), Θ (.),p(m+n)	1.717
Chaffinch (*Fringilla coelebs*)	398	Ψ(.), Θ (.),p(m+h)	1.266
Common redpoll (*Carduelis flammea*)	398	Ψ(.), Θ (.),p(m+h)	0.731

Indices of abundance

Comparison of indices of abundance from observer and ARD methods (for the top 16 species) revealed varied strengths of relationship between indices for different species, and the nature of the relationship often changed for different index values (i.e. did not produce a straight line; Fig. 6). These loess curves also indicated differences between habitat types for many species, although in some cases this may be due to small sample sizes for non-forest and shrubland habitats (Table 5). Results of GLMM analysis also revealed inconsistent relationships between API and observer indices for different species, with the effect size often varying in different habitat types (Table 6). In forest, the effect size ranged from 0.018 (kākā; *Nestor meridionalis*) to 0.303 (rifleman); in non-forest it ranged from -0.262 (rifleman) to 0.339 (chaffinch); and for shrubland the range was -0.070 (whitehead) to 0.571 (rifleman). Although for some species the effect sizes were similar for different habitat types (e.g. kākā: 0.018 for forest, 0.019 for shrubland), for most species they were quite variable (e.g. rifleman: 0.303 for forest, -0.262 for non-forest, 0.571 for shrubland). Effects of wind and noise on indices were variable and not consistent between species (Appendix 4).

Method efficiency

The observer-based count method was clearly more time-efficient than the ARD method, mainly due to the longer processing time requirements of the latter (Table 7). It was estimated that approximately 30 minutes was required to process each ARD 5-minute period. In a scenario where 10 bird counts were completed for a sampling location (2 rounds of 5 counts), an estimated 24.5% additional time would be required for the ARD method, compared to observers. In a scenario where only 5 bird counts were complete (1 round of counts), this increased to an estimated 92.5% additional time required for the ARD method.

The number of skilled ornithologists required to carry out the field observations was much higher than that required to process the ARD recordings. A total of 55 field observers were employed to carry out observer counts over the three survey seasons, completing a mean of 20.22 (± 2.78 SE) counts per person. It is worth noting that 44% of these completed less than 10 counts each (less than 1% of the total). ARD processing employed 13 people, who processed a mean of 150.54 (± 22.70 SE) 5-minute periods per person. When split by survey season a similar pattern was observed, with the ARD method requiring fewer people, each processing a larger proportion of 5-minute periods (Table 8).

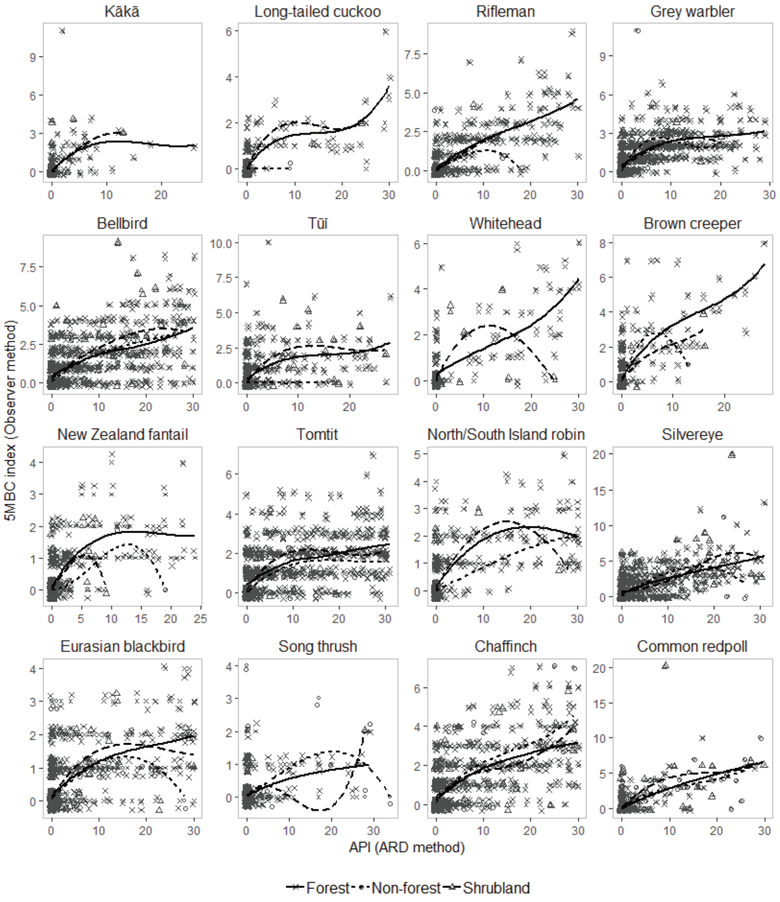

Figure 6. Comparison of observer index of abundance and Acoustic Prevalence Index (API) for the 16 most frequently-occurring species. Loess curves show the relationship between indices from the two methods for each habitat type. Individual data points have been displayed using jittering to make those with the same values visible.

Table 5. The number of 5-minute count periods in which each species was detected by at least one method (observer or ARD), for each habitat type.

Species	Forest	Non-forest	Shrubland	All habitats
Kākā (*Nestor meridionalis*)	65	1	9	75
Long-tailed cuckoo (*Eudynamys taitensis*)	63	3	4	70
Rifleman (*Acanthisitta chloris*)	270	13	14	297
Grey warbler (*Gerygone igata*)	513	38	56	607
Bellbird (*Anthornis melanura*)	503	62	53	618
Tūī (*Prosthemadera novaeseelandiae*)	223	13	23	259
Whitehead (*Mohoua albicilla*)	73	0	7	80
Brown creeper (*Mohoua novaeseelandiae*)	115	15	11	141
New Zealand fantail (*Rhipidura fuliginosa*)	181	5	15	201
Tomtit (*Petroica macrocephala*)	523	36	41	600
North/South Island robin (*Petroica longipes/australis*)	181	7	9	197
Silvereye (*Zosterops lateralis*)	399	71	69	539
Eurasian blackbird (*Turdus merula*)	257	51	37	345
Song thrush (*Turdus philomelos*)	71	26	11	108
Chaffinch (*Fringilla coelebs*)	366	85	56	507
Common redpoll (*Carduelis flammea*)	74	79	36	189

Table 6. Results of GLMM analysis to test for relationships between API (ARD) and observer 5-minute bird count (OBS) indices of abundance, in the three habitat types (hab). API values were normalized by subtracting the mean, and then dividing by the standard deviation. Estimates presented are for effects of ARD on OBS in each habitat type (each fitted with its own unique intercept and slope). Wind (w) or noise (n) were included where these improved model fit and sampling location (sl) was included as a random effect. For grey warbler, kākā, long-tailed cuckoo, and tūī, non-forest data were excluded due to small samples sizes causing problems with the models. There were no non-forest data for whitehead.

Species	**Model definition**	**Habitat type**	**Estimate**	**Standard error**
Kākā (*Nestor meridionalis*)	OBS ~ hab / ARD + w + n + (sl)	Forest	0.018	0.034
		Shrubland	0.019	0.095
Long-tailed cuckoo (*Eudynamys taitensis*)	OBS ~ hab / ARD + w + (sl)	Forest	0.076	0.031
		Shrubland	0.096	0.148
Rifleman (*Acanthisitta chloris*)	OBS ~ hab / ARD + n + (sl)	Forest	0.303	0.030
		Non-forest	-0.262	0.352
		Shrubland	0.571	0.233
Grey warbler (*Gerygone igata*)	OBS ~ hab / ARD + n + (sl)	Forest	0.216	0.025
		Shrubland	0.253	0.109
Bellbird (*Anthornis melanura*)	OBS ~ hab / ARD + w + (sl)	Forest	0.281	0.035
		Non-forest	0.332	0.142
		Shrubland	0.177	0.096
Tūī (*Prosthemadera novaeseelandiae*)	OBS ~ hab / ARD + n + (sl)	Forest	0.041	0.033
		Shrubland	0.099	0.083
Whitehead (*Mohoua albicilla*)	OBS ~ hab / ARD + w + (sl)	Forest	0.141	0.033
		Shrubland	-0.070	0.179
Brown creeper (*Mohoua novaeseelandiae*)	OBS ~ hab / ARD + n + (sl)	Forest	0.135	0.020
		Non-forest	0.005	0.128
		Shrubland	0.156	0.092
New Zealand fantail (*Rhipidura fuliginosa*)	OBS ~ hab / ARD + n + (sl)	Forest	0.106	0.031
		Non-forest	0.173	0.246
		Shrubland	-0.071	0.262
Tomtit (*Petroica macrocephala*)	OBS ~ hab / ARD + n + (sl)	Forest	0.255	0.032
		Non-forest	0.078	0.169
		Shrubland	0.100	0.154
North / South Island robin (*Petroica longipes/australis*)	OBS ~ hab / ARD + n + (sl)	Forest	0.144	0.032
		Non-forest	0.050	0.159
		Shrubland	-0.075	0.148
Silvereye (*Zosterops lateralis*)	OBS ~ hab / ARD + w + (sl)	Forest	0.267	0.031
		Non-forest	0.205	0.080
		Shrubland	0.294	0.063
Eurasian blackbird (*Turdus merula*)	OBS ~ hab / ARD + n + (sl)	Forest	0.183	0.036
		Non-forest	-0.011	0.130
		Shrubland	0.156	0.102
Song thrush (*Turdus philomelos*)	OBS ~ hab / ARD + n + (sl)	Forest	0.024	0.064
		Non-forest	-0.007	0.073
		Shrubland	0.094	0.092
Chaffinch (*Fringilla coelebs*)	OBS ~ hab / ARD + n + (sl)	Forest	0.290	0.034
		Non-forest	0.339	0.078
		Shrubland	0.228	0.087
Common redpoll (*Carduelis flammea*)	OBS ~ hab / ARD + w + (sl)	Forest	0.223	0.059
		Non-forest	0.184	0.038
		Shrubland	0.173	0.047

Table 7. Comparison of estimated time required per sampling location for observer and ARD methods, for two scenarios: (1) 10 bird counts completed; (2) 5 bird counts completed.

Bird counts completed	Method	Estimated time required (minutes)		
		Field	Data processing	Total
10	ARD	360	300	660
10	Observer	440	90	530
5	ARD	360	150	510
5	Observer	220	45	265

Table 8. Number of people employed and effort per person (mean number/percentage of counts completed) for observer (OBS) and ARD methods.

	2011–12		2012–13		2013–14		All seasons	
	ARD	OBS	ARD	OBS	ARD	OBS	ARD	OBS
No. of people	6	20	9	26	11	28	13	55
Mean no. counts/person	74.7	11.6	47.2	12.7	98.5	19.7	150.5	20.2
Mean % counts/person	16.7	2.2	11.1	4.0	9.1	3.7	7.7	1.9

DISCUSSION

Detection of species-richness

The loess model curves indicate that in general, as species-richness recorded by the ARD method increased, so did species-richness recorded by the observer method (or vice-versa). Clearly there is much variation, with the ARD method recording more species at some sampling locations and the observer method recording more species at others; however, the overall relationship appears to be reasonably consistent between habitat types. The number of non-forest sampling locations at which the observer method detected species and the ARD method did not, suggests that the observer method may have an advantage in this habitat type. Results from GLMM analysis indicated some differences between species-richness estimates for the two methods in different habitat types, although effect sizes were small. For all habitat types, the observer tended to record higher species-richness. The effect, though small, was highest for non-forest habitats. These results conflict with findings from some previous studies, which revealed that either there were no significant differences in ability to detect species-richness (Haselmayer & Quinn 2000; Celis-Murillo *et al*. 2009; Celis-Murillo *et al*. 2012) or that ARDs detected more species (Wimmer *et al*. 2013). Hutto & Stutzman (2009), however, found that observers detected a higher number of species, which was more consistent with our results. The differing conclusions of these studies may be influenced by variations in sample design, survey methods, location, environments sampled and/or species present; however, some considerations may be generally applicable. One of the main advantages of ARDs is that they produce a permanent record which can be reviewed multiple times (Haselmayer & Quinn 2000), whereas a field observer has only one chance to identify and record all species. At a location with high species-richness, this may give the ARD method an advantage. Haselmayer & Quinn (2000) found that data from audio recordings detected more species than field observers for sites with high species-richness, which was explained by having the ability to listen repeatedly to the ARD recordings, whereas observers can be over-whelmed in a field situation. An obvious advantage of the observer method, however, is the ability to detect species visually. In particular, this would potentially enable the observer to detect more species in open habitats (such as non-forest) or where there are species present that vocalise infrequently.

In this study, it could be that the visual detection advantage of observers has enabled them to detect higher numbers of species, especially in non-forest habitats which are generally more open environments. Perhaps the ability to visually detect species outweighed the ARD advantage of being able to repeatedly listen to recordings. In a study by Celis-Murillo *et al*. (2012), some species were detected more often by observers in pasture and coastal scrub, where greater visibility was thought to improve the likelihood of visual detection. In forest, however, where detections of these species were mostly auditory, the ARD method was at least as effective as the observer method. In this study, the observer advantage of being able to detect species visually may have been reduced at sampling locations in forest and shrubland habitats.

The cumulative mean number of species detected did not significantly differ between methods, suggesting that in this respect the two methods were equally effective and that the same number of stations (and therefore counts) were required to achieve similar species-richness detection. The cumulative mean number of species detected increased significantly for both methods, as the number of bird count stations increased, further reinforcing the importance of completing multiple bird counts at a location to maximise detection probability (MacKenzie & Royle 2005). The upward slope of the species accumulation curve between 4 and 5 bird count stations (Fig. 4) suggests that 5 stations may not be sufficient to detect all species present, and that to achieve this, further stations (bird counts) might be required. However, consideration must be given as to whether additional effort at the sampling location would justify the cost (Southwood & Henderson 2000; MacLeod *et al*. 2012).

Detection of individual species

Occupancy modelling revealed that habitat influenced detection probabilities for most species and wind and noise were often important. Most species included in this analysis were generally considered forest species, and therefore were more likely to be present in forest or shrubland habitats; not surprisingly probability of detection was highest in these habitats. For chaffinch, the difference was less pronounced, which may reflect its more generalist habitat requirements. It is perhaps less clear why habitat did not influence detection probabilities sufficiently to be included in the models selected for brown creeper, New Zealand fantail, and whitehead, as these species would normally occur in forest and shrubland rather than non-forest habitats. It is not surprising that wind and noise affected detection probabilities; previous studies have demonstrated that noise can have a negative effect (Simons *et al*. 2007; Pacifici *et al*. 2008), whilst wind can have the additional effect of influencing bird behaviour thereby reducing call frequency (O'Connor & Hicks 1980). As shown in Appendix 3, however, increasing wind and noise did not always appear to have a corresponding negative effect on detection probability. For the maximum wind value of 3, detection probability was higher when compared to wind value 2 for some species (e.g. bellbird and brown creeper). Similarly, a wind value of 0 had an apparent negative effect on detection probability for grey warbler (*Gerygone igata*), whereas a wind value of 1 had a positive effect. Some exceptions to the general pattern were also noted for noise, e.g. for Eurasian blackbird (*Turdus merula*) and kākā. The reasons for this are not obvious; however, smaller sample sizes for higher wind and noise values potentially resulting in unreliable results could partly explain these findings. It is also worth noting that the conditions during which 5-minute bird counts were conducted were, to a certain degree, self-censoring. That is, the observer was more likely to abandon the count in strong winds or when noise levels were high. This would also apply to ARDs, as recordings with high levels of noise would most likely be excluded from processing, hence the relatively small sample sizes for high wind and noise values.

Species detection probabilities, when compared between methods, were in most cases similar irrespective of habitat type. There were, however, a few instances (mostly in forest) where detection probabilities were different between the two methods, namely: bellbird, brown creeper, North Island/South Island robin and, to a lesser extent, tūī and rifleman (Fig. 5). Detection probability for bellbird was higher for the ARD method, whereas conversely for tūī it was higher for the observer method. There is no obvious explanation for these differences, unless it is related to species identification error, as both methods rely on manual identification of calls by observers or processors to generate data. There were 26 5-minute periods in which the ARD method detected bellbird only and the observer method detected tūī only, and a further 9 5-minute periods in which the ARD method detected tūī only and the observer method detected bellbird only. This suggests some degree of identification confusion between these two species, which could explain apparent differences in detection probability. Mortimer & Greene (2017) have also demonstrated that bellbird and tūī were frequently confused when the same ARD recordings were processed by two independent processors, due to these two species having similar-sounding calls. The apparent difference in detection probability for rifleman (in forest) is less obvious. One possibility, however, is that their high frequency calls (around 7–12 kHz; Mortimer 2013) can be missed by field observers, whereas the use of sonograms when processing ARD recordings could give a visual clue to the presence of this species.

Identification issues could potentially partly explain the difference in detection probabilities for brown creeper, as their calls can sound similar to, and therefore have the potential to be confused with yellowhead (mohua; *Mohoua ochrocephala*; Falla *et al*. 1966; Higgins & Peter 2002). It is unlikely, however, that this was a major cause for differences in detection probabilities, as Mortimer *et al.* (2019) established that confusion with mohua or other species was only occasional, and mohua has a much more restricted geographic range compared to brown creeper (Robertson *et al.* 2007). The potential for misidentification does, however, emphasise the need to quantify error rates so that these can be accounted for in analyses (Mortimer & Greene 2017).

Another possible explanation is that a large proportion of brown creepers were detected visually by observers, and consequently not detected by ARDs. ARD processors were unlikely to fail to detect brown creepers in large single-species flocks, as they have a tendency to keep in almost constant vocal contact with one another (Dean 1990). When in smaller groups, however, they can often be silent for many minutes (Henderson 1977; Cunningham 1985). Brown creepers also commonly occur in mixed species flocks consisting of silvereye (*Zosterops lateralis*), New Zealand fantail, grey warbler, parakeets (*Cyanoramphus* spp.), chaffinch and/or common redpoll (Henderson 1977; Dean 1990; Heather & Robertson 2000; Higgins & Peter 2002). On occasions when multiple species are calling simultaneously, it may be difficult to reliably pick out brown creeper calls. Under these circumstances, the visual advantage of the observer may enable them to identify brown creepers more often than ARD processors.

The ability of observers to detect birds visually is the most likely explanation for the higher detection probability of North/South Island robin, for the observer method. Vocalisations of this species are generally loud and distinctive and therefore we would expect both methods to be effective at detecting when birds are calling. However, the robin's habit of foraging close to the observer, in a quiet and unobtrusive manner (Higgins & Peter 2002), may result in many visual-only detections from observers, missed by the ARD method. This could be tested by re-analysing the data, including only aural records from field observers. However, since the mode of detection (aural or visual) was not recorded for the Tier 1 Monitoring Programme bird counts, this was not possible.

Another possible explanation for differences in species detection is that distance and/or frequency ranges vary between observers and ARDs. There will be some within-method variability, as both methods are affected by observer/processor hearing ability, which will vary between individuals and is affected by age and gender (Pearson *et al*. 1995). In some instances (e.g. rifleman), lack of agreement may be influenced by an inability to hear bird calls at higher frequencies. It is possible, however, that detection also varies between methods, due to limitations of human hearing and ARD technology. Although Celis-Murillo *et al*. (2009) concluded that their observers and ARDs had similar auditory ranges and consequently sampled equal areas, a comparison of detection ranges for Tier 1 Monitoring ARDs and observers has not been undertaken. Pryde & Greene (2016) tested ARD detection range for morepork (*Ninox novaeseelandiae*), but did not compare this to human observers. Never-the-less, we propose that detection ranges are likely to be similar for both methods, because if they were not then we would expect to observe a systematic difference in detection probability for all species. Environmental effects, such as sound attenuation, weather, and noise, could also affect detection (Morton 1975); however, since the two methods relied on human hearing for species detection (and the recordings were not noise-filtered or altered in any way), we would expect these effects to influence both methods and not result in significantly different detection differences.

Indices of abundance

Loess curves and results of GLMM analysis indicated considerable variation in strength and nature of relationship between indices from the two methods, both for different species and different habitat types for the same species. These results suggest, therefore, that ARDs were limited to detecting presence. The ARD index was a measure of call activity, which would be influenced by many factors including weather conditions (Keast 1994), presence of an observer (Gutzwiller *et al*. 1994; McShea & Rappole 1997), habitat, and species density (McShea & Rappole 1997). To our knowledge, there are no detailed studies of factors influencing call activity specifically for New Zealand birds; however, according to Dowding (2012), call rates are influenced by a number of factors, and this would make it extremely difficult to relate these to abundance. From ARD data, we would not be able to ascertain if multiple calls were from different birds or a single individual. In contrast, a field observer can estimate, using direction and distance, an approximation of the actual number of birds calling. In the absence of data for actual numbers of birds present, our study makes the assumption that the observer method produces an index which is representative of species abundance. We recognise, however, that this may not be the case, as such an index is not adjusted for detection probability and can be affected by a wide range of variables including time of year, time of day, habitat, weather, environmental noise, and observer ability (Dawson 1981). Although observer indices of this kind have received considerable criticism from a number of sources (e.g. Farnsworth *et al*. 2002; MacKenzie & Kendall 2002; Rosenstock *et al*. 2002; Buckland 2006), several studies have demonstrated their ability to detect actual changes in species abundance (Murphy & Kelly 2001; Elliott *et al*. 2010; Greene & Pryde 2012). It is beyond the scope of this study to assess the accuracy of unadjusted indices of abundance. However, we believe that despite their limitations, indices of abundance from the observer method can be used to indicate major changes in relative abundance, and therefore a relationship (or lack of) between this and the ARD method index may provide an indication of whether or not the latter also has potential to show population trends.

An alternative approach to estimating species abundance using ARDs could be via use of ARD arrays (Dawson & Efford 2009; Efford *et al*. 2009). This technique estimates density from the spatial pattern of detection, using signal strength to improve precision. This approach shows promise and investigation into potential incorporation of this into DOC's monitoring programme is currently underway.

Method efficiency

Estimates of time taken per sampling location for the Tier 1 Monitoring Programme suggested that the observer method was most efficient, largely due to the additional time required for processing of ARD recordings. ARDs also required some additional field time, since two visits to each bird count station were required (one for deployment and a second for retrieval), whereas observer counts could be completed with a single visit to each station. The disparity in processing times resulted from the different processes involved to produce data in digital format for the two methods. For observer count data, it was simply a matter of manually entering data into a custom database with built-in data validation checks, which could be done relatively quickly. The ARD recordings, however, required careful listening, often multiple times, and recording presence of species in each 10-second block. Essentially the difference was that the majority of the identification work using observers was done whilst in the field, whereas with ARDs it was done upon return to the office. The field worker heard the 5-minute period once only, whilst the ARD processor could listen to the recorded 5-minute period as many times as they felt necessary. The ARD method would gain considerable efficiency if manual processing was replaced by automated call recognition. In 2014, DOC investigated the potential of recurrent neural network (RNN) techniques for automated call recognition of morepork, kiwi (*Apteryx* spp.), and weka (*Gallirallus australis*; Bagnall & Abraham 2014). Unfortunately, this has so far proved to be unreliable for Tier 1 bird data, with too many false positives and false negatives (*unpubl. data*). There has also been much recent research by others in this area, exploring various techniques (e.g. Chou *et al*. 2008; Bardeli *et al*. 2010; Chu & Blumstein 2011; Lopes *et al*. 2011; Towsey *et al*. 2012; Lasseck *et al*. 2018; Priyadarshani *et al*. 2018). DOC is continuing to explore possibilities in this area; however, at present automated call recognition is not sufficiently developed for incorporation into the Tier 1 Monitoring Programme.

Although the observer method appeared to be the most time-efficient for the Tier 1 Monitoring Programme, this may not necessarily apply to other projects as it will depend largely upon study objectives and design. Hobson *et al*. (2002) estimated that for their purposes the use of automated recording devices and associated manual processing would be more cost-effective than employing specialist ornithologists to carry out field surveys, whilst Wimmer *et al*. (2013) found use of field observers to be more time-efficient than ARDs. With this in mind, we recommend that for any monitoring programme in which efficiency is paramount, a pilot study is completed to test how potential methods perform within the proposed sampling design. Choice of method must also consider the data outputs and their ability to address the objectives of the programme (e.g. to determine species presence or estimate abundance). Use of ARDs, whilst potentially less efficient, could provide an alternative solution in circumstances where employing traditional observer-based methods is challenging, such as monitoring of nocturnal birds or across a large spatial scale. Another important consideration is cost of equipment (for example ARDs, processing software, and file storage). In addition to the initial cost, there will also be periodic repair, upgrade and/or replacement costs. These costs were not included in this study; however, they could be critical to the choice of method when finances are limited.

The high proportion of people who completed <10 observer counts reflects the difficulties the Tier 1 Monitoring Programme experienced in sourcing experienced ornithologists in the long-term. This was particularly the case for the first few survey seasons, although more recently it has been less of an issue, with most people employed for a full survey season (*unpubl. data*). Where presence-only data are sufficient, this difference in staff requirements suggests that the ARD method may be desirable in situations where skilled field observers are in short-supply or not available during the field season – an advantage of ARDs noted by other researchers (Hobson *et al*. 2002; Celis-Murillo *et al*. 2009). Further efficiencies could be made for observer counts by using electronic data capture devices, reducing the need for data entry time (van Tamelen 2004). The potential of such tools is currently being investigated for the Tier 1 Monitoring Programme.

Comparison of ARDs and observers, specifically the similar detection probabilities, reduced time-efficiency of ARDs and inability of ARDs to record abundance (and associated trends), resulted in the decision to discontinue processing of diurnal ARD recordings from the 2014–15 survey season onwards. Processing of nocturnal recordings continued, since there was no other source of data for this time period (i.e. no night-time observer counts). Diurnal recordings will continue to be collected, so that should techniques in automatic bird call recognition become sufficiently advanced, these recordings can be processed retrospectively. We must stress that in our study we have compared data from observers to that from a single type of ARD only, and that different results may be obtained from other ARDs.

Conclusions

The results show that for species-richness detection, observers generally recorded more species than ARDs; however, the overall differences were small. Detection probabilities for individual species were similar between methods for most species. Exceptions were probably due to either identification confusion or species behaviour resulting in visual-only detection by observers. The results suggested that ARDs may be limited to the collection of presence data, whereas observer counts could also monitor abundance (via indices or estimates of density). This may change with further technological developments, for example through the use of ARD arrays to calculate density. In this study, observer counts proved to be more time-efficient, mainly due to the relatively long processing time required for ARD recordings. Potential future technological developments in automated species identification could significantly reduce processing times, however. Higher numbers of skilled people were required for observer counts, which may make them less suitable in the absence of a dedicated team and if there is a shortage of appropriately skilled field observers during the survey season.

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Appendix 1. Environmental variables recorded during the observer 5-minute bird counts.

Variable	Score	Definition
Temperature	1	<0°C
	2	0–5°C
	3	6–10°C
	4	11–15°C
	5	16–22°C
	6	>22°C
Sun	0–5	Approximate number of minutes sun overhead
Precipitation (type)	M	Mist
	R	Rain
	H	Hail
	S	Snow
Precipitation (value)	0	None
	1	Dripping foliage
	2	Drizzle
	3	Light
	4	Moderate
	5	Heavy
Wind	0	Leaves still or move without noise
	1	Leaves rustle
	2	Leaves and branchlets in constant motion
	3	Branches or trees sway
Noise	0	Not important
	1	Moderate
	2	Loud

Appendix 2. Land Cover Database (LCDB) classifications (Thompson *et al*. 2003) included in each habitat type assigned to bird count stations, used in species occupancy and GLMM analyses.

Habitat type	LCDB classifications included
Forest	Broadleaved Indigenous Hardwoods; Deciduous Hardwoods; Exotic Forest; Indigenous Forest
Non-forest	Alpine Grass/Herbfield; Depleted Grassland; Fernland; Flaxland; Gravel or Rock; Herbaceous Freshwater Vegetation; Herbaceous Saline Vegetation; High Producing Exotic Grassland; Lake or Pond; Landslide; Low Producing Grassland; Permanent Snow and Ice; River; Sand or Gravel; Short-rotation Cropland; Tall Tussock Grassland
Shrubland	Gorse and/or Broom; Manuka and/or Kanuka; Matagouri or Grey Scrub; Mixed Exotic Shrubland; Sub Alpine Shrubland

Appendix 3. Effects of wind and noise on detection probabilities (untransformed estimates of coefficients); *n* = the number of 5-minute count periods with each wind or noise value; NA = not applicable (i.e. the covariate was not included in the model).

Species	**Survey covariate estimate ± SE$_{mean}$**						
	Wind				**Noise**		
	0	**1**	**2**	**3**	**0**	**1**	**2**
	n = 401	**n = 572**	**n = 83**	**n = 38**	**n = 722**	**n =302**	**n = 60**
Kākā (*Nestor meridionalis*)	NA	NA	NA	NA	-0.4619 ± 0.0004	-1.0008 ± 0.0005	1.4628 ± 0.0006
Long-tailed cuckoo (*Eudynamys taitensis*)	NA	NA	NA	NA	NA	NA	NA
Rifleman (*Acanthisitta chloris*)	0.4758 ± 0.0003	-0.0158 ± 0.0002	0.3530 ± 0.0003	-0.8130 ± 0.0003	NA	NA	NA
Grey warbler (*Gerygone igata*)	-0.2044 ± 0.0002	0.5006 ± 0.0002	0.1107 ± 0.0002	-0.4069 ± 0.0002	NA	NA	NA
Bellbird (*Anthornis melanura*)	0.4206 ± 0.0002	-0.1517 ± 0.0002	-0.9432 ± 0.0003	0.6742 ± 0.0002	0.8434 ± 0.0002	-0.1018 ± 0.0001	-0.7418 ± 0.0002
Tūī (*Prosthemadera novaeseelandiae*)	NA	NA	NA	NA	0.6399 ± 0.0002	-0.1890 ± 0.0002	-0.4509 ± 0.0002
Whitehead (*Mohoua albicilla*)	1.6778 ± NA	1.4974 ± NA	-0.0846 ± NA	0.8415 ± NA	NA	NA	NA
Brown creeper (*Mohoua novaeseelandiae*)	1.0065 ± 0.0004	-0.0468 ± 0.0002	-1.4787 ± 0.0005	0.5189 ± 0.0003	NA	NA	NA
New Zealand fantail (*Rhipidura fuliginosa*)	0.4352 ± 0.0005	0.0254 ± 0.0004	0.5409 ± 0.0005	-1.20013 ± 0.0007	NA	NA	NA
Tomtit (*Petroica macrocephala*)	0.3286 ± 0.0002	0.2301 ± 0.0002	0.2798 ± 0.0002	-0.8387 ± 0.0003	0.3139 ± 0.0002	0.0236 ± 0.0001	-0.3374 ± 0.0002
North/South Island robin (*Petroica longipes/australis*)	0.9766 ± 0.0005	0.3451 ± 0.0004	-0.4244 ± 0.0004	-0.8976 ± 0.0005	NA	NA	NA
Silvereye (*Zosterops lateralis*)	NA	NA	NA	NA	0.2424 ± 0.0002	-0.2035 ± 0.0002	-0.0389 ± 0.0001
Eurasian blackbird (*Turdus merula*)	0.1305 ± 0.0002	0.4580 ± 0.0003	-0.6860 ± 0.0003	0.0972 ± 0.0002	0.4866 ± 0.0002	-0.1446 ± 0.0002	0.3420 ± 0.0002
Song thrush (*Turdus philomelos*)	NA	NA	NA	NA	0.8386 ± 0.0004	-0.2526 ± 0.0003	-0.5860 ± 0.0004
Chaffinch (*Fringilla coelebs*)	NA	NA	NA	NA	NA	NA	NA
Common redpoll (*Carduelis flammea*)	NA	NA	NA	NA	NA	NA	NA

Appendix 4. Effects of wind and noise on observer method index of abundance (untransformed estimates of coefficients); *n* = the number of 5-minute count periods with each wind or noise value; NA = not applicable (i.e. the covariate was not included in the model). There are no estimates for wind or noise value 0, as these were used as the reference categories by the models (REF).

Species	**Survey covariate estimate ±SE$_{mean}$**						
	Wind				**Noise**		
	0	**1**	**2**	**3**	**0**	**1**	**2**
	n = 401	**n = 572**	**n = 83**	**n = 38**	**n = 722**	**n =302**	**n = 60**
Kākā (*Nestor meridionalis*)	REF	0.1603 ± 0.4023	-0.3158 ± 0.6018	-0.5432 ± 0.5049	REF	-0.2282 ± 0.2847	1.1005 ± 0.2909
Long-tailed cuckoo (*Eudynamys taitensis*)	REF	-0.1779 ± 0.3064	0.7887 ± 0.4124	0.4352 ± 0.4786	NA	NA	NA
Rifleman (*Acanthisitta chloris*)	NA	NA	NA	NA	REF	0.2271 ± 0.1127	0.3087 ± 0.2089
Grey warbler (*Gerygone igata*)	NA	NA	NA	NA	REF	0.0985 ± 0.0728	0.1314 ± 0.1218
Bellbird (*Anthornis melanura*)	REF	-0.1492 ± 0.1072	-0.4282 ± 0.2287	-0.0611 ± 0.2405	NA	NA	NA
Tūī (*Prosthemadera novaeseelandiae*)	NA	NA	NA	NA	REF	-0.1515 ± 0.1534	0.2596 ± 0.2591
Whitehead (*Mohoua albicilla*)	REF	0.2973 ± 0.1975	-0.0398 ± 0.3304	-0.2968 ± 0.6307	NA	NA	NA
Brown creeper (*Mohoua novaeseelandiae*)	NA	NA	NA	NA	REF	0.0044 ± 0.1751	-0.0662 ± 0.2571
New Zealand fantail (*Rhipidura fuliginosa*)	NA	NA	NA	NA	REF	0.2369 ± 0.1584	0.2137 ± 0.3043
Tomtit (*Petroica macrocephala*)	NA	NA	NA	NA	REF	-0.0651 ± 0.0798	-0.1208 ± 0.1614
North/South Island robin (*Petroica longipes/australis*)	NA	NA	NA	NA	REF	0.1589 ± 0.1458	0.3038 ± 0.2282
Silvereye (*Zosterops lateralis*)	REF	-0.1772 ± 0.0972	0.0264 ± 0.1448	-0.0671 ± 0.2483	NA	NA	NA
Eurasian blackbird (*Turdus merula*)	NA	NA	NA	NA	REF	0.2109 ± 0.1202	-0.0399 ± 0.2699
Song thrush (*Turdus philomelos*)	NA	NA	NA	NA	REF	-0.1024 ± 0.3463	-0.6268 ±1.0363
Chaffinch (*Fringilla coelebs*)	NA	NA	NA	NA	REF	0.0424 ± 0.0929	-0.0176 ± 0.1889
Common redpoll (*Carduelis flammea*)	REF	0.0951 ± 0.1707	-0.4263 ± 0.3116	-0.2345 ± 0.4128	NA	NA	NA

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Parameters influencing selection of nest boxes by little penguins (*Eudyptula minor*)

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Abstract: Little penguins (*Eudyptula minor*) readily breed and moult in nest boxes. The selective placement of nest boxes can enhance their use, improve breeding success and increase recruitment. I examined nest parameters for 171 nest boxes at Pilots Beach, southern New Zealand, in relation to their use for breeding and for moulting in the 2016 breeding season. Linear models to assess the relative importance of nest box parameters produced definitive results where a higher likelihood of use was interpreted to indicate a preference. The only preference for breeding or moulting was for shaded boxes that were free of vegetation at ground level. These trends were supported by comparisons of proportions of boxes used for breeding and moulting that indicated shaded boxes surrounded by bare ground were preferred to unshaded boxes surrounded by introduced grasses. Proportions also indicated that boxes on flat ground with a flat entrance were preferred to boxes on sloped ground or a sloped entrance for breeding and moulting. About half of the boxes between 61 and 90 m distance to the landing were used for breeding and moulting. Females nesting in shaded boxes had a higher breeding success than those in unshaded boxes but their chick masses were similar. To optimise nest box use by little penguins and encourage recruitment, nest boxes ideally should be placed under bushes or artificial structures on open ground up to 90 m from the landing.

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Key words: New Zealand, breeding success, moult, habitat, accessibility

INTRODUCTION

Little penguins (*Eudyptula minor*) are colonial burrow-nesting seabirds found in southern Australia and New Zealand (Marchant & Higgins 1990). This species has been divided into two lineages, Australian and New Zealand, based on genetic, morphological, and behavioural characteristics (Peucker *et al.* 2009; Grosser *et al.* 2015). The Australian lineage encompasses Australia and south-eastern New Zealand, with the remainder belonging to the New Zealand lineage. The breeding biology of the Australian lineage has been studied extensively in Australia (e.g. Fortescue 1999; Dann *et al.* 2000) and in New Zealand (e.g. Johannesen *et al.* 2002; Agnew *et al.* 2014). Little penguins from the Australian lineage can lay a second clutch after successfully raising the first resulting in two broods in one breeding season, termed double brooding (Gales 1985).

Natural burrows of little penguins have been supplemented with nest boxes at some locations in New Zealand (Houston 1999; Johannesen *et al.* 2002; Agnew *et al*. 2014) and in Australia (Wienecke *et al.* 2000; Daniel *et al.* 2007; Sutherland *et al.* 2014). The penguins prefer nest boxes to natural burrows at some locations (Houston 1999; Agnew *et al.* 2014), and nest boxes can improve breeding success and generate local population increases (Perriman & Steen 2000; Sutherland *et al.* 2014). Nest boxes are also a bonus for research because their contents are easier to monitor than natural burrows (Priddel &

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Carlile 1995; Perriman & Steen 2000; Johannesen *et al.* 2003).

The use of nest boxes by little penguins from the Australian lineage breeding at Pilots Beach, Taiaroa Head, Otago Peninsula, South Island, New Zealand was investigated in this study (Fig. 1). Little penguins were studied at Taiaroa Head in the 1980s by Gales (1985) who found only one pair breeding at, or in the vicinity of, Pilots Beach (Dann 1994). Nest boxes (an unknown number) were first deployed at Pilots Beach in 1987 and some were promptly occupied by penguins (Houston 1999). In the 1992/93 breeding season 29 nests were found at Pilots Beach (McKinlay and Perriman 1995), followed by 15 nests in 1993/94 and 17 nests in 1994/95 (Perriman 1997). In the early 1990s, about 20 nest boxes were placed throughout the colony (L. Perriman *pers. comm.*) and from the early 2000s another 150 wooden nest boxes were added to facilitate undisturbed use by little penguins in the presence of uncontrolled public access (H. Langsbury *pers. comm.*). About 50 nest boxes were placed from 2015 to 2017 by high school students.

In 2012 Blue Penguin Pukekura (2018) started guided tours each evening at a raised wooden platform accessed by a raised wooden walkway and positioned to overlook the beach for visitors to view little penguins returning from the sea. The present study was initiated in September 2016 by the Pukekura Trust (Korako Karetai Whanau/ Otago Peninsula Trust, Joint Venture) to investigate the population size and breeding success of little penguins at Pilots Beach. The purpose of this investigation is to inform and facilitate on-going conservation efforts to restore the local fauna and flora as part of the owner's *kaitiakitanga* (guardianship) obligations. Students from local high schools contributed to the data collection as part of the community science project. Here I report the first year of investigating nest box use by penguins for breeding and for moulting in relation to habitat parameters of each nest box at Pilots Beach. Determination of the importance of parameters that influence the selection of nest boxes by little penguins will help ensure the optimal placement of boxes and development of habitat to facilitate future population growth.

METHODS

Study area

This study extended from September 2016 to April 2017 at Pilots Beach, beside Taiaroa Head at the northern tip of Otago Peninsula (45°46.6′S, 170°43.7′E) (Fig. 1). It is a 2 ha fenced area abutting Otago Harbour, with a maximum distance from the foreshore at mean high tide to the perimeter fence of 124 m. The substrate is sand. The original habitat here was cleared at least 150 years ago with the present vegetation a mix of shrubs and trees; mainly native ngaio (*Myoporum laetum*) and poroporo (*Solanum laciniatum*), with introduced tree lupin (*Lupinus arboreus*) and elderberry (*Sambucus nigra*). Ground cover comprises of introduced marram (*Ammeophila arenaria*) and pasture grasses growing to 1 m tall, along with South African iceplant (*Carpobrotus edulis*) growing to 20 cm tall. Grasses and iceplant form a barrier difficult to traverse by penguins. The ground is bare under shrubs and trees and under the walkway and viewing platform.

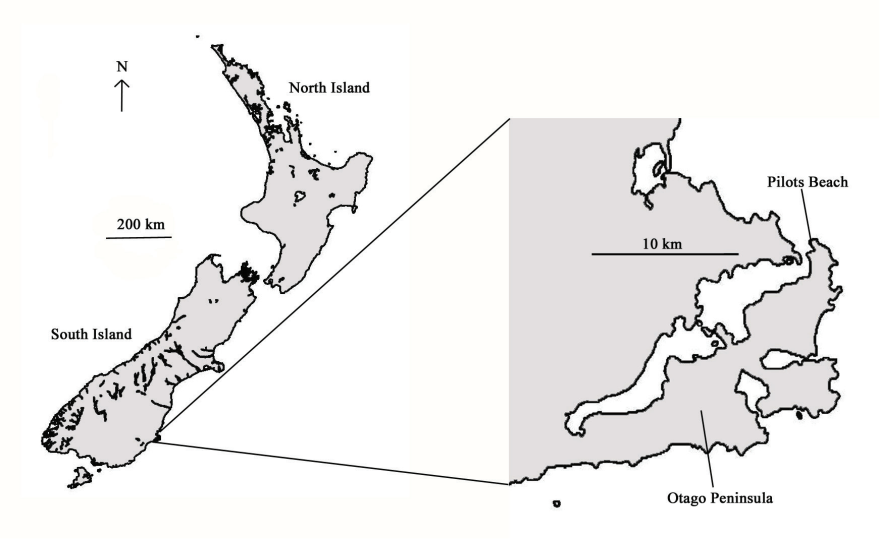

Figure 1. Map showing the location of Pilots Beach (45°46.6′S, 170°43.7′E), Otago Peninsula, South Island, New Zealand.

No precise records exist for the number and timing of deployment of nest boxes but the total is likely to be in the range 200–250. These nest boxes are of two designs. 'Old' boxes were deployed from 1987 to 2009; they were made with treated timber 20 mm thick and are 500 mm long, 400 mm wide and 290 mm tall, with an entrance tunnel along the long side 200 x 200 x 170 mm. 'New' boxes were deployed from 2012 to 2016; they are made of 10 mm thick treated plywood and are 440 x 500 x 250 mm with an entrance tunnel along the long side 200 x 180 x 150 mm. All boxes sit horizontally and are on flat ground or embedded into slopes.

Records for several decades of air temperature data at Taiaroa Head (Weather Station 5355) abutting Pilots Beach have been collated by the National Institute of Water and Atmospheric Research in The National Climate Database (2018). Some years had missing data and available records ceased in 2002, 14 years before this study began. Monthly data for each calendar year were realigned to match 12-month little penguin seasons from May of the year breeding started to April of the following year. Three monthly air temperature parameters were investigated: mean daily maximum for 32 of the seasons from 1967 to 2001; extreme maximum for 31 of the seasons from 1967 to 2001; and number of days with maximum ≥25.1°C for 28 of the seasons from 1972 to 2001.

Monitoring regime

The little penguin population was not enumerated in this first season of this study. Locating nest boxes was difficult as many were either buried in sand or hidden in long grass or under iceplant. Some remained undiscovered in 2016. In addition, natural burrows were found throughout the colony but not monitored because most were too deep (>1 m) to determine their contents without causing disturbance to the penguins.

Nest boxes were monitored twice weekly for adult attendance and breeding activity. Breeding parameters were assigned to females (not to males or to breeding pairs) following Agnew *et al.* (2014). Single broods were defined as the sum of all single clutches (only one clutch laid) and replacement clutches (a total of two or more clutches after the previous clutch was unsuccessful) that produced no more than a single brood in one season. Double broods were defined as a clutch laid after the first brood successfully fledged (Gales 1985; Agnew *et al.* 2014). Egg lay dates before the start of regular monitoring on 6 September 2016 were back-calculated from hatch dates, where duration of incubation averages 36 days (Marchant & Higgins 1990).

All adult little penguins encountered were implanted with Allflex 11 mm passive integrated transponder (PIT) tags supplied in sterile individually packed needles. These were injected into the loose skin at the neck and sealed with Opsite (Smith & Nephew Medical Ltd) to prevent loss of the PIT tag and infection. In case the PIT tag failed or was lost, each penguin was also externally marked on the outside web of the right foot with a small, self-piercing, numbered metal tag supplied by the New Zealand Department of Conservation. These tags, called No. 1 wing tags, are made of stainless steel (3 mm wide and 20 mm long and designed as ear tags for small mammals). If the outside web on the right foot was torn or damaged the web tag was placed either on the inside web of the right foot or on the outside of the left foot. There is no tag loss evidence to date.

When first encountered all adults were sexed by measuring their bills following Hocken & Russell (2002) and Gales (1988), and by observation of breeding mate affiliation (Johannesen *et al.* 2003) although this method is not 100% reliable (Renner & Davis 1999; Hocken & Russell 2002). Most chicks were weighed at about 6 weeks and marked in the same way as adults. Their bills were not measured as they could not be sexed (Johannesen *et al.* 2003) because bill size increases with age until breeding age (Hocken & Russell 2002).

After the completion of breeding little penguins undergo an obligatory annual moult ashore (Reilly & Cullen 1983). The presence of moulting penguins or discarded feathers were recorded for each box.

Nest box parameters

Information for eight parameters were collected for each nest box to determine how they were related to the selection of nest boxes by little penguins

Entries for three parameters were continuous numbers.

Distance to landing: Latitude and longitude for each nest box were recorded using a hand-held Garmin Oregon 400c GPS unit. Estimated Position Error was not recorded. Using the GPS coordinates of each nest box the distance from the main penguin landing site (yellow arrow in Fig. 2 & Fig. 3) to the nest box was calculated with Google My Maps. The distance of each nest box to the landing was then assigned to one of four categories: 1–30 m, 31–60 m, 61–90 m and >90 m.

Entrance facing: the compass direction of the entrance was recorded using a Laser Technology Inc. TruPulse 360°B laser range finder and entered in degrees.

Entries for five parameters had one of two options.

Shade: the exposure of nest boxes to sunlight was assigned as 'shaded' for boxes underneath the viewing platform and walkway or underneath shrubs and trees, or as 'unshaded' for boxes exposed to direct sunlight.

Ground vegetation (vegetation): the vegetative cover at ground level within a 1m diameter around the nest box was assigned as 'absent' if it had no vegetation and 'present' if it had vegetation.

Entrance topography: the topography in front of the entrance of the box was either 'flat' and had a flat area of at least 10 cm x 10 cm in front of the entrance of the nest box or 'sloped' if it lacked this flat area.

Box topography: the topography surrounding the nest box was either 'flat' when the box was on flat ground or on slopes <10° or 'sloped' when the boxes were embedded into slopes >10°.

Box age: there were two designs of nest boxes present in the colony and they were assigned to one of two options: 'old' or 'new' (defined earlier).

Statistical analyses

Means were compared using t-tests and proportions were compared using binomial tests. A 4x2 Chi-squared test was used to determine a pattern of nest box use for breeding and moulting at the four categories of distance to the landing. Akaike's information criterion (AIC) was used to determine whether nest box parameters were related to the use of nest boxes for breeding and moulting. The Akaike model weight for the data provides a relative weight or importance for each model relative to the entire set (Johnson & Omland 2004). If the value of the difference between each model and the best model (ΔAIC) was ≤2 it was considered to have substantial support (Burnham & Anderson 2004).

RESULTS

Use of nest boxes

A total of 175 nest boxes were located by 30 April 2017, of which 80 (46%) were used for breeding (Fig. 2) and 103 (59%) were used for moulting (Fig. 3). These totals included 66 (38%) used for both breeding and moulting. No boxes were both unshaded and surrounded by bare ground. Four boxes were both shaded and surrounded by ground vegetation with none of these boxes used for breeding and two used for moulting. These four were subtracted from the total of 175 nest boxes resulting in a total of 171 nest boxes used in analyses (80 used for breeding and 101 used for moulting). Shade and ground vegetation were then treated as one box parameter ('shade/vegetation') with the two options 'shaded/absent' and 'unshaded/present'.

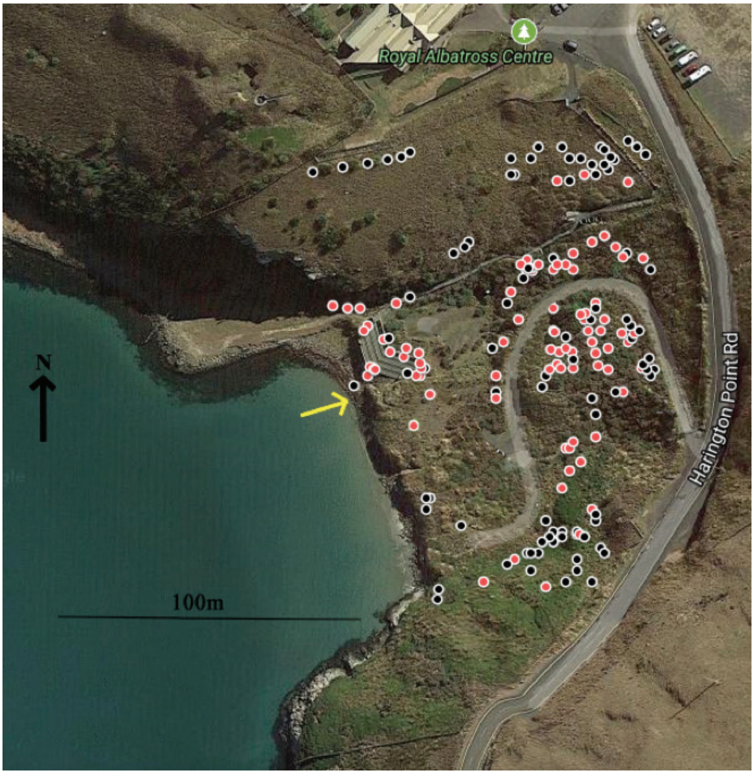

Figure 2. Nest box positions at Pilots Beach in the 2016 season for boxes used (red circles) or not used (black circles) for breeding; the yellow arrow indicates the main landing site; positions plotted on Google My Maps.

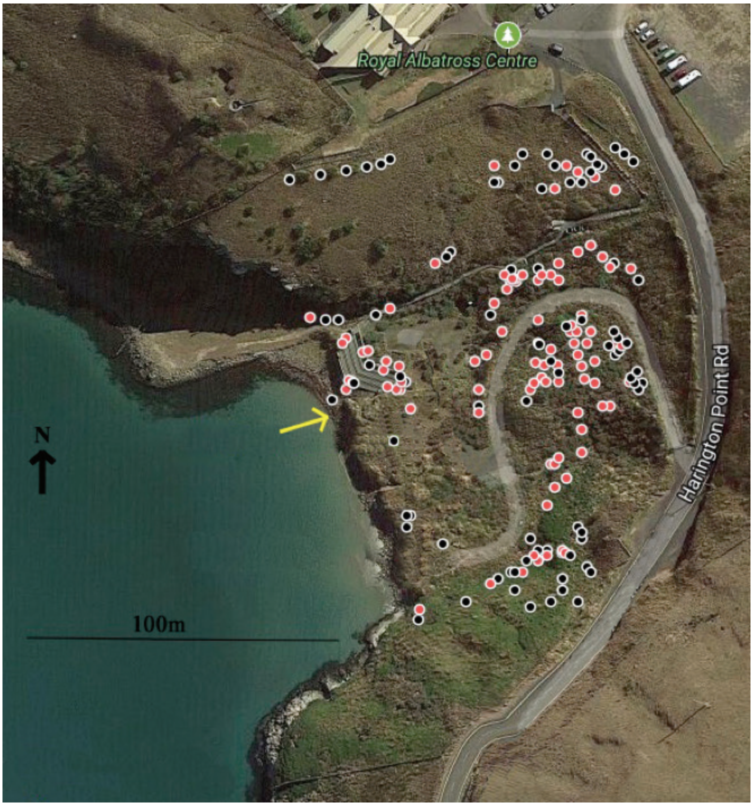

Figure 3. Nest box positions at Pilots Beach in the 2016 season for boxes used (red circles) or not used (black circles) for moulting; the yellow arrow indicates the main landing site; positions plotted on Google My Maps.

Over half of nest boxes used for breeding were 61–90 m from the landing and 21% were within 30 m of the landing. (Table 1), a statistically significant pattern. Nest boxes used for moulting showed a similar significant pattern (Table 1).

Significantly more boxes were used for breeding that were shaded and surrounded by bare ground (Table 2). They also had flat entrances, were on flat ground and were old (Table 2). Only boxes that were shaded and surrounded by bare ground and were on flat ground were used significantly more often for moulting (Table 2)

Table 1. Comparison of the distance to landing categories (in 30 m intervals) for nest boxes used for breeding or moulting. N is the number of boxes for each nest box use.

		Proportion at					
Nest box use	**N**	**0–30 m**	**31–60 m**	**61–90 m**	**>91 m**	**Chi**	**P**
breeding	80	0.21	0.06	0.55	0.18	19.952	<0.001
not breeding	91	0.05	0.11	0.41	0.43		
moulting	101	0.18	0.09	0.56	0.17	24.965	<0.001
not moulting	70	0.06	0.09	0.34	0.51		

Table 2. Comparison of box use by breeding and moulting penguins for the four nest box parameters presented as options. n_T is the total number of boxes in each option for each parameter; n is the number of boxes in each option used for breeding or moulting. Proportions (ppn) were compared with binomial tests where 95% CL shows the 95% confidence limits.

	Nest box parameter	Options	n_T	n	ppn	95% CL	Z	P
Breeding	Shade/vegetation	shaded/absent	54	42	0.78	0.64–0.88	5.354	<0.001
		unshaded/present	117	38	0.33	0.23–0.41		
	Entrance topography	flat	153	77	0.50	0.42–0.59	2.458	0.014
		sloped	18	3	0.17	0.04–0.41		
	Box topography	flat	101	58	0.57	0.47–0.67	3.194	0.001
		sloped	70	22	0.31	0.21–0.44		
	Box age	old	126	71	0.56	0.47–0.65	4.021	<0.001
		new	45	9	0.20	0.10–0.35		
Moulting	Shade/vegetation	shaded/absent	54	45	0.83	0.71–0.92	4.217	<0.001
		unshaded/present	117	56	0.48	0.39–0.57		
	Entrance topography	flat	153	94	0.61	0.53–0.69	1.587	0.113
		sloped	18	7	0.39	0.17–0.64		
	Box topography	flat	101	69	0.68	0.58–0.77	2.798	0.005
		sloped	70	32	0.46	0.34–0.58		
	Box age	old	126	82	0.65	0.56–0.73	2.500	0.124
		new	45	19	0.42	0.28–0.58		

The combination of shade and ground vegetation was the most important nest box parameter (ΔAIC ≤2) for breeding and moulting penguins. This parameter respectively accounted for 17% (Model 1) and 11% (Model 7) of the variation in data (Table 3).

Table 3. Models examining the variation in nest box parameters in relation to nest box use for breeding or moulting in the 2016 season. AIC is the Akaike's information criterion; ΔAIC is the value of the difference between each model and the best model; w_i are the Akaike weights; R^2 is the proportion of model deviance accounted for by each parameter.

Model	Parameter	ΔAIC	w_i	R^2	AIC
	breeding				
1	Shade/veg	0	1.00	0.17	220.0
2	Box age	14.97	0.00	0.10	234.9
3	Distance (30 m)	20.34	0.00	0.00	240.3
4	Box topography	21.93	0.00	0.00	241.9
5	Entrance topography	27.00	0.00	0.00	247.0
6	Entrance facing	33.53	0.00	0.94	253.5
	moulting				
7	Shade/veg	0	0.86	0.11	228.1
8	Distance (30 m)	3.73	0.13	0.09	231.8
9	Box topography	11.43	0.00	0.05	239.5
10	Box age	13.08	0.00	0.04	241.2
11	Entrance topography	18.34	0.00	0.01	246.5
12	Entrance facing	20.38	0.00	0.00	248.5

Air temperatures

Monthly mean maximum daily temperatures at adjacent Taiaroa Head peaked at averages of 17.3°C in January and 17.2°C in February (with respective maxima of 19.6°C and 19.9°C) from data for 32 seasons ending in 2001. The corresponding most extreme maximum daily temperature was 31°C. Daily maximum temperatures equalled or exceeded 25°C on 57 days, equivalent to 4% of days from data for 28 seasons. These 57 days were spread though the six months from October to March with 63% (36 days) in January or February.

Breeding success

In the 2016 season 74 nest boxes were used for breeding by 71 females. Of these, 62 females had single broods (which include replacement clutches) and they used 65 nest boxes, i.e. some females used a different box for the second clutch. Nine females used nine boxes for double-brooding. Each of 62 single-brood females fledged an average 1.74 chicks and each of the nine double-brood females fledged an average of 3.22 chicks (Table 4).

Table 4. Breeding success for little penguins at Pilots Beach for the 2016 season.

	Single broods	Double broods	Total
Number of females	62	9	71
Number of clutches laid	66	18	84
Eggs laid	132	36	168
Chicks hatched	112	31	143
Chicks fledged	108	29	137
Mean chicks fledged/female	1.74	3.22	1.93

The mean number of chicks fledged from shaded boxes surrounded by bare ground was significantly higher than that from unshaded boxes surrounded by grasses or iceplant (Table 5). None of the other comparisons generated significant difference in the mean number of chicks fledged. None of the comparisons of options for nest box parameters generated significant difference in the mean peak mass of chicks (Table 6). No pattern of the number of chicks fledged per box or the mean mass of chicks at the four categories of the distance to the landing were observed (Table 7).

Table 5. The mean number of chicks fledged per box for the two options for each of the four nest box parameters; n_B is the number of nest boxes; n_c is the number of chicks.

Nest box parameter	Options	n_B	n_c	Chicks/box	Range	sd	t	P
Shade/vegetation	shaded/absent	39	80	2.05	0–4	0.69	2.297	0.0246
	unshaded/present	35	57	1.63	0–4	0.88		
Entrance topography	flat	71	131	1.88	0–4	0.80	0.316	0.7532
	sloped	3	6	2.00	1–3	1.00		
Box topography	flat	52	100	1.92	0–4	0.76	1.179	0.2421
	sloped	22	37	1.68	0–3	0.89		
Box age	old	66	124	1.88	0–4	0.83	0.829	0.4096
	new	8	13	1.63	1–2	0.52		

Table 6. Mean body mass (g) of chicks at peak mass (age 6 weeks ± 4 days) in relation to four nest box parameters; n_B is the number of nest boxes; n_c is the number of chicks.

Nest box parameter	Options	n_B	n_c	Mass (g)	Range (g)	sd	t	P
Shade/vegetation	shaded/absent	24	52	1,127	500–1,460	172	0.150	0.8818
	unshaded/present	16	28	1,135	710–1,380	153		
Entrance topography	flat	37	74	1,135	500–1,460	160	0.730	0.4696
	sloped	3	6	1,063	710–1,290	227		
Box topography	flat	29	59	1,132	500–1,460	171	0.102	0.9192
	sloped	11	21	1,126	710–1,340	164		
Box age	old	37	76	1,140	500–1,460	161	2.002	0.0525
	new	3	4	948	820–1,140	136		

Table 7. The number of chicks fledged per nest box at the four categories of distance to the landing; and the mean body mass (g) of chicks at peak mass (age 6 weeks ± 4 days) in relation to four categories of distance to the landing; n is the number of nest boxes.

Distance to landing	n	Chicks/box	n	Mass (g)	Range (g)	sd
0–30 m	13	2.00	4	1,156	920–1,320	143
31–60 m	5	1.80	4	1,227	1,020–1,410	139
61–90 m	43	1.79	27	1,115	500–1,460	176
>90 m	13	1.92	5	1,128	990–1,290	100

DISCUSSION

Shaded nest boxes surrounded by bare ground at Pilots Beach were used for breeding and for moulting by little penguins in preference to unshaded boxes surrounded by vegetation at ground level. There was also higher breeding success in shaded boxes than in unshaded boxes, although there was no difference in the mass of their chicks. All shaded boxes were surrounded by bare ground because the local ground-cover vegetation at Pilots Beach thrives only in sunny conditions. As Pilots Beach lacks native ground-cover species, introduced grasses and South African iceplant dominate and can form vegetative barriers difficult for penguins to traverse. Consequently, the preference for shaded boxes here may be a preference for easy access rather than for shade.

The most obvious reason for selecting shaded boxes is to minimise the likelihood of encountering high air temperatures. Little penguins ashore increase oxygen consumption at ambient temperatures >25°C (Baudinette *et al.* 1986), expend more energy at >27°C (Dann & Chambers 2013), and hyperventilate at >35°C (Baudinette *et al.* 1986; Stahel & Nicol 1988). Avoidance of high temperatures may impact on the timing of the breeding season: in Australia little penguins breed earlier in the year in the west than in the east, a difference attributed to avoidance of the hotter summer temperatures in the west (Klomp *et al.* 1991). Daily maximum air temperatures ≥25°C occurred on only 4% of days through 28 seasons at Pilots Beach. This indicated that temperatures in the range that challenge little penguins are rare and so avoidance of high temperatures is unlikely to be the key cause for the preference for shaded nest boxes.

Little penguins preferentially used nest boxes between 61 and 90 m from the landing for both breeding and moulting. However, linear models did not detect this preference as important for either breeding or moulting. The greater mass of penguins prior to moulting makes walking more energy demanding and laborious (Pinshaw *et al.* 1977; Reilly & Cullen 1983; Gales *et al.* 1988), perhaps making shorter distances more important during moult than during breeding. This possibility seems unlikely because it should also apply to breeders: little penguins that nest closer to the sea spend less energy walking and deliver larger amounts of food to their chicks (Miyasaki & Waas 2003).

Comparisons of means or proportions detected other preferences that were not regarded as important from linear models. Breeders preferred boxes on flat ground with a flat area in front of the entrance. Older boxes (deployed >7 years) were preferentially used for breeding but not for moulting. Little penguins have a high nest-site fidelity (Johannesen *et al.* 2002): they tend to re-use the same site annually and so older boxes are more likely to be used for breeding. The direction faced by the entrance of the box was not important for either breeding or moulting.

This investigation of the use of nest boxes for breeding and for moulting provided insight into their optimal placement. The key prerequisite is unimpeded penguin access to the sea. To optimize nest box use by little penguins and encourage recruitment, nest boxes ideally should be placed in shaded sites with open ground.

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Birds and bats of Rotuma, Fiji

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Abstract: Rotuma, Fiji, is a small and isolated island in the Central Pacific, rarely visited by ornithologists. We present here our own observations on the avifauna, obtained in 1991 and in 2018, completed by previous records obtained since the 19th Century. The main changes on the species composition concern the extirpation of the white-throated pigeon and the settlement of the reef heron. The status of the four endemic landbirds (one species and three subspecies) is good, especially that of the Rotuma myzomela. However, the recent arrival of the common myna (2017–2018) represents a potential threat. We also observed that the Pacific sheath-tailed bat, which was abundant 30 years ago, has probably been extirpated from the island.

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Key words: bats, birds, Emballonura, Fiji, Myzomela, Rotuma

INTRODUCTION

Rotuma is a small and remote island, located between the Fijian archipelago and the Tuvalu Islands (Fig. 1). Compared to the three main nearby archipelagos (Fiji, Samoa, and Tonga), it has few seabird colonies and a low number of landbirds. The study of bones obtained from archaeological excavations has demonstrated the recent loss of species on many tropical Pacific islands (Steadman 2006). On Rotuma, the Maka Bay excavation (1991–1996) produced a faunal sample of thousands of vertebrate specimens, including birds, but unfortunately the avian bones have not yet been identified (Allen *et al.* 2001), so the past avifauna of Rotuma remains unknown. The island has been rarely surveyed for birds, despite the occurrence of several endemic taxa. We present here an update of the list of birds of Rotuma based on surveys conducted in 1991 by DW and 2018 by JCT and AC. The data of the 2018 survey were initially compiled in an unpublished report (Cibois & Thibault 2019), which forms the basis of the present article. We compare these data with previous surveys conducted between the 19th Century and the 1980's.

METHODS

Island characteristics

Rotuma is a volcanic group, very isolated in the Pacific Ocean, located 12°30′ S latitude and 177′°E

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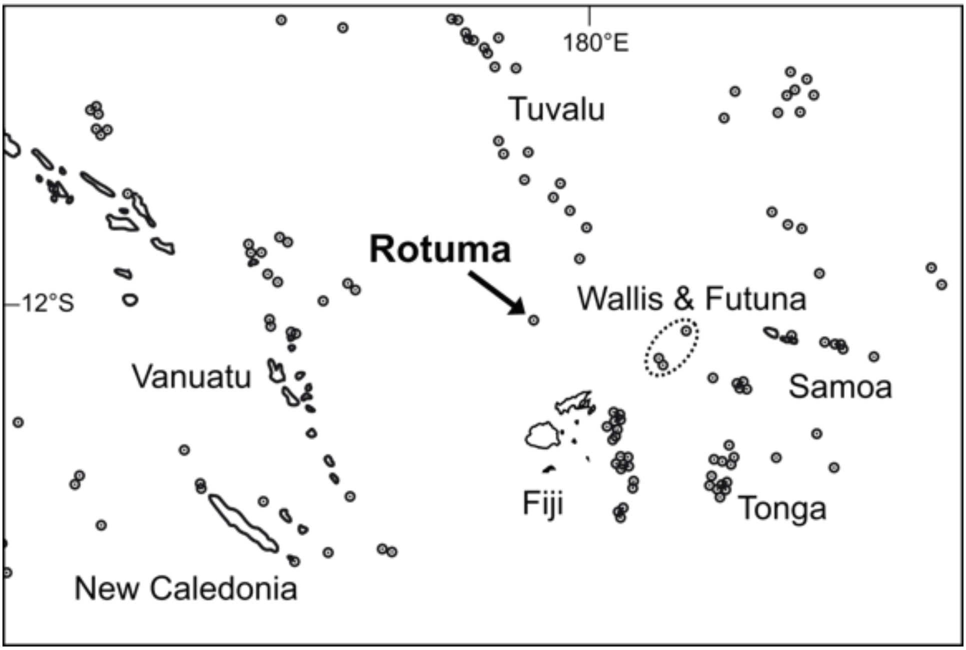

Figure 1. Map showing location of Rotuma and the main archipelagos of the Central Pacific.

longitude. It lies 465 km away from the nearest Fijian island (Yasawa I Rara) and *c.* 1,000 km from the Pentecost Island in Vanuatu. Its closest non-Fijian neighbours are Nukulaelae, an atoll in Tuvalu, 450 km to the north east, and Futuna, part of the French Overseas Collectivity of Wallis & Futuna, 545 km to the east (Fig. 1). Rotuma comprises 10 islands, the largest of which, called Rotuma, is 13 km long and 4 km wide and has an area of about 44 km² (Fig. 2). The group is of Pleistocene origin (*c.* 1.5 million years old) with Holocene lava flows (Woodhall 1987). Uea is the second largest island, having a surface area of just over 1 km². It is the highest of the group, having an elevation of 260 m. Aside from Rotuma, the islands are currently uninhabited and irregularly visited by the Rotuman people. Some of these islets are refuges for rare native plants and also support seabird colonies. The population of Rotuma is estimated at *c.* 2,000, distributed among 7 districts. Although Rotuma is politically part of Fiji, it is a Polynesian outlier that speaks a Polynesian language (Howard & Rensel 2007).

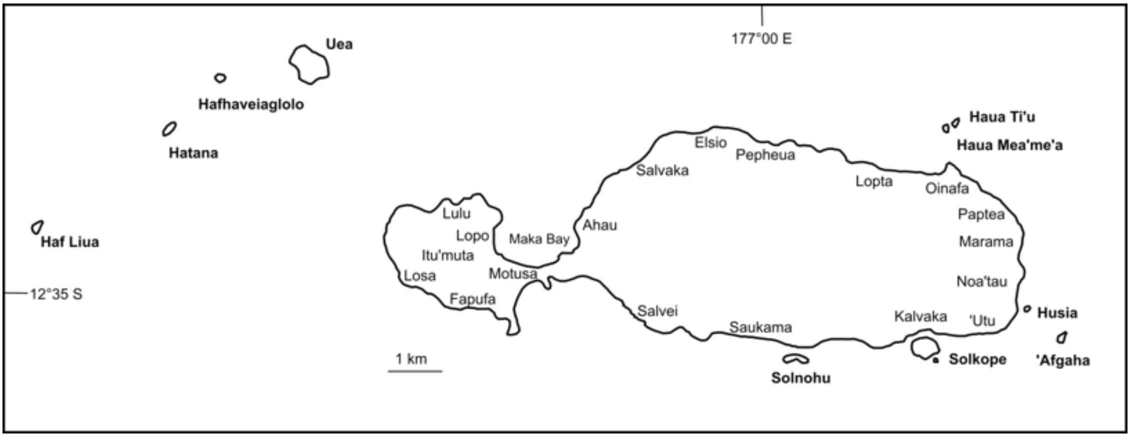

Figure 2. Map of Rotuma, main villages, and islets. The toponymy follows Howard & Rensel (2007), except for the name Itu'muta (one of the district names) that we use to refer to the entire peninsula.

Data collection

Bird specimens were obtained by several scientific expeditions that travelled to the Fijian islands during the 19th and 20th Centuries. The French expedition on the vessel "La Coquille" was one of the first known scientific expeditions to travel to Rotuma, in April 1824. However, the account of the naturalist and health officer René Primevère Lesson, who published many data on Pacific birds, contains nothing on natural history and presents a detailed account only on the Rotuman people (Lesson 1829; see http://www.hawaii.edu/oceanic/rotuma/os/Lesson.html for an English translation). The earliest specimen (a myzomela) arrived in Europe before 1846, but its collector is unknown. This specimen was used as a model for the plate included in Gray's original mention of the species (Gray 1844–1849). The British Museum (UK) received in the 1870s several specimens from G. Brown, an English missionary (Forbes 1878; Wiglesworth 1891; Neumann 1927). The British zoologist J. Stanley Gardiner collected birds on Rotuma in 1896 (Gadow 1898). The Whitney South Sea Expedition stopped on Rotuma from 18 to 25 May 1925 (Correia MS; Watling 1985). More than 130 birds were collected, now held at the American Museum of Natural History, New York. They represent the largest collection of specimens from Rotuma. The most recent contributions on Rotuman birds include: Clunie (1985) from 30 November to 5 December 1985; Zug *et al.* (1988) from 6 to 26 May 1987; DW from 24 July to 3 August 1991 (mainland, and Uea, Haf Liua, Hatana islets); Mizota & Naikatini (2007) from 3 to 10 September 2005 (Hatana islet); the surveys conducted in the 2000s during two "EcoCamps" organized by the NGO LäjeRotuma (Anon. A, B); AC and JCT from 21 September to 23 October 2018. During the 2018 visit, we surveyed the coastal areas, most of Itu'muta Peninsula, several areas inland (in particular around Noa'tau), and one islet ('Afgaha). The identity and presence of species was confirmed visually, but for future molecular studies we also collected blood samples from 86 mist-netted individuals. The status of each species was then compared to previous surveys.

ANNOTATED CHECKLIST

We follow the nomenclature of Gill & Donsker (2019), except for the buff-banded rail for which we used the generic name *Hypotaenidia* (instead of *Gallirallus*, see Thibault & Cibois 2017). The endemic status of four taxa is indicated by an asterisk after their scientific name. We used McClatchey *et al.* (2000) and Meyer (2017) for plant identification and nomenclature. Detailed species accounts for the other Fijian islands can be found in Watling (2004).

Undetermined duck (Anatidae)

No species recorded, but the Rotuman name ME'JIA "*wild duck*" (Churchward 1940) support the occasional visits of ducks.

Red Junglefowl (*Gallus gallus*)

Introduced. Present all over the island, although more common in villages than in secondary forests, where it is feral.

Feral pigeon (*Columba livia*)

Introduced. Deliberately introduced at an unknown date after 1991. First mentions in 2008–2009 (Anon. B), qualified then as "*fairly common*". In 2018, a single individual seen in Motusa on 30 September and on 12 October, and a flock of 5 individuals on 22 October in Ahau.

Metallic (White-throated) pigeon (*Columba vitiensis*)

Extirpated. Not recorded by visitors during the 19th Century (G. Brown, J.S. Gardiner). In his diary (23 May 1925, p. 234), Correia (MS) indicated he saw both the "*Samoa pigeon*" and the "*black pigeon*", identified as Pacific imperial pigeon and metallic pigeon, respectively (Correia used these two names consistently in his Journal). However, no specimens of these pigeons were collected on Rotuma (Watling 1985), and only Clunie (1985) mentioned the metallic pigeon on Rotuma again: "*now very scarce and shy, my only seeing one, and otherwise only hearing its mournful call on four occasions*". This species was searched for in 1991, then in 2018, but vainly. Therefore, its status on Rotuma remains uncertain: did a small breeding population become extinct, or do small groups visit the island occasionally?

Pacific imperial pigeon (*Ducula pacifica*)

Breeder. Recorded by all observers. Present all over the main island. Also observed on Uea (1991) and 'Afgaha (2018), and probably a regular visitor in all surrounding islets. Commoner in the villages and farmlands than in the secondary forests where food resources are less abundant. In 2018, we observed single individuals, couples or adults with a juvenile. The lack of larger groups suggests the birds may be territorial. Hunting is rare today, and most birds are very tame, even in villages. The favourable situation encountered on Rotuma is probably exceptional, with a total number estimated at 5,000–10,000 individuals on the island. We recorded birds eating or foraging in the following plant species: *Artocarpus altilis* (fruits also eaten on the ground), fruits of *Calophyllum inophyllum*, *Cananga odorata*, *Elaeocarpus* cf. *tonganus*, *Flacourtia rukam*, cultivated

Sandalwood *Santalum* sp., *Spondias dulcis* and of the palm *Pritchardia pacifica*; also leaves of *Papaya carica* (reducing the leaf to a lace-like pattern).

Crimson-crowned (Purple-capped) fruit dove (*Ptilinopus porphyraceus*)
Breeder. The taxonomy of this species is complex, with four taxa treated as subspecies (Dickinson & Remsen 2013), three species (Pratt & Mittermeier 2016; Hayes *et al.* 2016; Gill & Donsker 2019), or four species (del Hoyo & Collar 2014). The taxa are: *ponapensis* from Chuuk and Pohnpei (Caroline Is.), *hernsheimi* from Kosrae (Caroline Is.), nominate *porphyraceus* from Fiji (small islands), Tonga and Niue, and *fasciatus* from Samoa. Cibois *et al.* (2014) showed that *ponapensis* and *porphyraceus* are not sister taxa, suggesting that the species group is not monophyletic, and Hayes *et al.* (2016) split *hernsheimi* from *ponapensis*. Pratt & Mittermeier (2016) consider the subtle differences between *porphyraceus* and *fasciatus* as not justifying separating them as species, but del Hoyo & Collar (2014) split them. Finally, del Hoyo & Collar (2014) considered a fifth taxon, *graeffei* from Wallis and Futuna, to be a hybrid *porphyraceus* X *fasciatus* population (an idea first expressed by Ripley & Birckhead 1942). Clearly the systematics of this group could profit from a denser genetic sampling. Collected by Correia in 1925 on Rotuma. Uncommon in the 1980's (Clunie 1985). Zug *et al.* (1988) observed the species only once. In 1991, found mainly in the more mature bush of the higher hills. In 2018, its situation was more favourable, as the bird was present all over the island, on the shore and inland, in farmlands, on the outskirts of villages, and in secondary forests. However, its density was considerably lower than that of the imperial pigeon. Also seen on ‘Afgaha (2018) but not on Uea (1991). We never observed more than two birds together and rarely in flight. Total number estimated at 500–1,000 individuals. We recorded birds eating fruits or foraging in the following plant species: *Cananga odorata*, *Ficus* sp., ivory nut palm (*Metroxylon warburgii*) (flowers only).

White-tailed tropicbird (*Phaethon lepturus*)
Breeder. Recorded both on the shore and inland in farmlands and secondary forests. Seen also on islets (Solkope, Haua Ti'u, Haua Mea'me'a, ‘Afgaha, Uea). Number estimated at a few hundred pairs. Breeds in holes of tall old trees (e. g. *Calophyllum inophyllum* and *Mangifera indica*), but also possibly in cliffs (on islets, or on the coast of Itu'muta).

Long-tailed cuckoo (*Urodynamis taitensis*)
Visitor. Only two sightings on Rotuma: Correia (MS) May 1925 and DW July–August 1991.

Buff-banded rail (*Hypotaenidia philippensis*)
Breeder. Common in the 1980s (Clunie 1985; Zug *et al.* 1988) and in 1991. In 2018, recorded everywhere on the coast and inland, in all kinds of habitat: beaches at low tide, villages, cultivations, secondary forests, grasslands. Less abundant in secondary forests. We observed approximately one individual per 50 m on the main road and on the farmlands' "feeder" roads, but its density in secondary forest was probably lower. Its presence on islets was demonstrated only for Uea in 1991.

Australasian swamphen (*Porphyrio melanotus*)
Breeder. Collected by Gardiner in 1896 (Gadow 1898), then by Correia in 1925 (Watling 1985). Uncommon in 1985 (Clunie 1985) and in 1991. Not recorded by Zug *et al.* (1988). Rarely recorded during the surveys in 2008–2009 (Anon. B). In 2018, recorded in 12 different localities, both on shore and inland. Mainly associated with farmlands and cultivations near the villages, and also in the grassland of Paptea School and along the airstrip. Not recorded in the secondary forests. Number tentatively estimated at more than one hundred birds. Considered a pest for banana and pineapple cultivations, but we did not see any traps or snares, and the villagers just use rags as scarecrows.

Petrels or shearwaters (Procellariidae)
No petrel or shearwater has been formally identified on Rotuma. However, evidences suggest the regular presence of Procellariidae on or near the island. Churchward (1940) mentioned two of them: FA'MÄNE for a "*bird seldom seen, but often heard at night-time. It has a habit of uttering its note twice in succession: the Rotumans say IA TŌŌ TĀR, i.e. it speaks and immediately answers*"; and TAIKO for a "*bird which utters at night-time a cry like that of a child*". The first name was also recorded in 2018. Generic names TA'I'O and TAIKO are attributed to several species of petrels in other Polynesian islands (Clark 1982). Another Rotuman name, TOIOKTA, recorded in 1991 and 2018, could also be attributed to petrels or shearwaters. It can be transliterated as TAI–OK, with a long TAI (call) followed by an abrupt OK (the fart), the bird having the reputation to fart and burp at the same time! Correia (MS) described "*a black bird which almost all the time in the sea and rests on the tops of the mountains, in the holes under the ground while nesting*". Several of our informants in 2018 described nocturnal birds, different from the eastern barn owl (*Tyto javanica*), calling in flight above the villages; other mentioned birds on islets entering burrows during the night (on ‘Afgaha, Haua Ti'u and Haua Mea'me'a islets). Pratt *et al.* (1987) list the wedge-tailed shearwater (*Ardenna pacifica*) as a likely resident, but hard evidence is lacking.

Pacific reef heron (*Egretta sacra*)
Breeder. First record in 2007 (Anon. A). It may have (re)colonized the island since 1991. In 2018, not abundant but regularly seen on all coasts and on the grassland of Paptea School. Seen on ʻAfgaha and it probably visits regularly all islets. Not recorded inland in the farmlands. For a total of 46 records, we observed 85% grey morphs (N=39) and 15% white morphs (N=7). Although we found no nests, the species undoubtedly breeds now on Rotuma.

White-faced heron (*Egretta novaehollandiae*)
Visitor. One individual seen in the grassland of Paptea School on 7 and 8 October 2018, and at the airport (maybe the same individual) on 23 October.

Lesser frigatebird (*Fregata ariel*)
Breeder. Recorded by previous observers, with single evidence of breeding, on Uea in 1991. In 2018, seen daily in flight, several dozen birds roosting in trees of Haua Ti'u and Haua Mea'me'a.

Great frigatebird (*Fregata minor*)
Visitor. Recorded in 2008–2009 (Anon. B), and in 2018 on several occasions, but less regularly than the lesser frigatebird.

Red-footed booby (*Sula sula*)
Breeder. Breeds on islets, but the inventory of sites remains incomplete and the total population is unknown. In 1991, a few nested in low vegetation on Haf Liua; in 2007 unknown numbers bred on Hatana (Mizota & Naikatini 2007). In 2018, several dozen birds roosted on Haua Ti'u and Haua Mea'me'a; not recorded on Solkope and ʻAfgaha.

Brown booby (*Sula leucogaster*)
Breeder. Breeds on islets, but the inventory of sites remains incomplete and the total number is unknown. In 1991 a major nesting site with probably several thousand pairs recorded on Haf Liua, and a few pairs on Uea and Hatana; breeding was confirmed again on Hatana in 2007 (Mizota & Naikatini 2007). In 2018, the remote islets were not visited, but small colonies (less than 10 pairs) were found on Haua Ti'u and ʻAfgaha, and a roosting place or a small colony on Haua Mea'me'a.

Pacific golden plover (*Pluvialis fulva*)
Visitor. Recorded by all observers. In September–October 2018, we recorded mostly isolated birds with a total number estimated at several hundred.

Lesser sand plover (*Charadrius mongolus*)
Visitor. A single record of one individual in winter plumage (showing some marks on the breast of summer plumage) seen on 22 October 2018 on a beach in front of Lopo.

Bristle-thighed curlew (*Numenius tahitiensis*)
Visitor. Photographed in October 1959 and seen twice in November–December 1985 (Clunie 1985).

Cf. **whimbrel** (*Numenius phaeopus*)
Visitor. One curlew seen briefly on 23 September 2018, on rocks bordering the Maka Bay at Lopo and then in flight, could possibly be attributed to this species.

Bar-tailed godwit (*Limosa lapponica*)
Visitor. Possibly an annual visitor, but noted only during the surveys of 2008–2009 (Anon. B).

Ruddy turnstone (*Arenaria interpres*)
Visitor. Recorded by all visitors, both during boreal winter and summer. In autumn 2018, it was the commonest shorebird with the Pacific golden plover, seen regularly on most of coasts of the mainland and on the islets (at least on ʻAfgaha and Haua Me'ame'a). Mainly in small flocks, up to 38 individuals, foraging at low tide on beaches, coral reefs, and on grasslands and lawns at high tide. A bird ringed in Japan during spring migration on 20 May 2018 (age estimated at least at 3 years; Australasian Waders Studies Group, email of 20 November 2018) was seen in Motusa and on the beach of Lopo from 30 September – 12 October 2018.

Red knot (*Calidris canutus*)
Visitor. Only recorded during the 2008–2009 surveys (Anon. B).

Sharp-tailed sandpiper (*Calidris acuminata*)
Visitor. One juvenile seen and photographed 16 October 2018 on the beach of Lopo.

Sanderling (*Calidris alba*)
Visitor. Recorded during the 2008–2009 surveys (Anon. B) and in 2018 on the beach of Lopo: one individual on 22 September and 26–27 September, and a darker individual on 1 October.

Pectoral sandpiper (*Calidris melanotos*)
Visitor. Seen and photographed twice in 2018: first

on 29 September on the road near Lopo, and second on 8 October on the grassland of Paptea School. Differences in coloration (bill, legs, nape, and breast) strongly suggest that two different juveniles were present.

Wandering tattler (*Tringa incana*)
Visitor. Recorded by all visitors, both during boreal summer and winter. In September–October 2018, it was commonly distributed on all the mainland shores, and probably on all islets. We found isolated birds every 50–100 m, but no flocks. Number estimated at several hundred birds.

Brown noddy (*Anous stolidus*)
Breeder. On mainland, it breeds in small number, mainly on the coast of Itu'muta, in cliffs or in trees, and locally in the coconuts of Oinafa. However, most breeders are on islets, on the ground and in trees on Haua Ti'u, Haua Mea'me'a, 'Afgaha, Solkope, Uea, and Hatana. No estimate of numbers available.

Black noddy (*Anous minutus*)
Breeder. Gardiner (in Gadow 1898) collected an immature bird. Recorded in 1991. In September–October 2018, a small colony (*c.* 10 pairs) bred in a big tree (*Calophyllum inophyllum*) along the shore in Oinafa Village. Birds were also probably breeding on the islets off Oinafa Village. No estimate of numbers available.

White tern (*Gygis alba*)
Breeder. Recorded by all observers since the 1920s. In 2018, patchily distributed on the mainland, both on the shore and inland; no colonies were found, but we observed isolated pairs, and small groups, up to ten individuals. Number on mainland estimated at a few hundred pairs. Recorded also on Solkope, 'Afgaha, Haua Mea'me'a and Haua Ti'u islets, totalizing several hundred pairs. Number on Hafana and Uea are unknown, but probably relatively high. No doubt that several thousand pairs breed on the Rotuma Group as a whole.

Sooty tern (*Onychoprion fuscatus*)
Breeder. The colony on Hatana Islet, which number was estimated at several thousand pairs (Mizota & Naikatini 2007), is one of six known colonies in Fiji.

Black-naped tern (*Sterna sumatrana*)
Breeder. Recorded in 1991 and one individual appears on a picture taken on an unknown islet during the 2008–2009 surveys (Anon. B). In September–October 2018, several pairs bred on Hau Mea'me'a Islet (feeding juveniles on 8 October) and several single birds or pairs were seen fishing in different places.

Swamp harrier (*Circus approximans*)
No known record, apart from linguistic evidences. Churchward (1940) mentioned the name RUTAI for a "*hawk*", a name known also by those Rotumans who know the bird in the main islands of Fiji.

Fiji goshawk (*Accipiter rufitorques*)
No confirmed record. Gardiner mentions it in Gadow (1898), where the name JERLEVA is attributed to a goshawk, "*repeatedly seen in Rotumah*" but no bird was collected. Correia (MS) tried unsuccessfully to obtain a specimen, and Clunie (1985) attributed Gardiner's mention to a Pacific long-tailed cuckoo.

Eastern barn owl (*Tyto javanica delicatula*)
Breeder. Recorded by all observers since the 19th Century, but in very small number. In September–October 2018, we noted it only four times in Itu'muta and inland, always in cultivated areas.

Rotuma myzomela (*Myzomela chermesina**)
Endemic breeder. In 1846, G.R. Gray first provided the name *chermesina* to a new species of bird belonging to the family of Meliphagidae, but from an unknown origin. He did not describe the bird but D.W. Mitchell illustrated a male. The description of the species was done subsequently in 1878 by W.A. Forbes, who compared the plate to the specimens sent by a missionary from Rotuma. Considered for a long time as a subspecies of the cardinal myzomela (*M. cardinalis*), it is now treated as a full species (Dickinson & Christidis 2014; del Hoyo & Collar 2016; Gill & Donsker 2019). According to the phylogenetic tree of the genus *Myzomela* proposed in Marki *et al.* (2017), the Rotuma myzomela is closely related to the Micronesian myzomela (*M. rubratra*) (an hypothesis also proposed by Koopman 1957). But their relationships with other myzomelas are unclear, in particular with the Samoan myzomela (*M. cardinalis nigriventris)*, never sequenced. Koopman (1957) suggested that the taxon from Samoa derived from the same ancestor as the cardinal myzomela from Vanuatu. Pratt & Mittermeier (2016) recognized the Samoan myzomela as a distinct species based on vocal and morphological differences compared to the Melanesian populations.

Very common all over the mainland, more frequent in open areas (villages, coastland, and farmlands) than in the dense secondary forests.

Present also on islets: Uea (1991), ‘Afgaha (2018), and it probably visits or stays on all islets; some birds do not hesitate to fly above the sea, as observed regularly in Maka Bay. However, the mainland is the main reservoir and most efforts of conservation should be concentrated there (the total area of the islets represents only less than 2 km² *vs*. 44 km² for the mainland). Using the data by F. Clunie in 1985 and DW in 1991, BirdLife International (2018) estimated the population number at 10,000–19,999 individuals. Estimate in 2018 based on observations and captures using mist-nets is within the same range, with a mean of five birds/ha in villages and farmland, and approximately one bird/ha in dense secondary forest. Thus, population number remained stable, at least for the last 30 years. However, the introduction of the common myna, feared by NatureFiji-MareqetiViti (Anon. C), occurred recently (see below) and its impact on the Rotuma myzomela population is uncertain. It forages in all vegetation levels, from grasslands to high trees. All observers admired its acrobatic feeding techniques, gleaning or hanging in the vegetation and, according to Clunie (1985), fly-catching. It forages mainly solely, but also in groups up to 20 or thirty birds – seen for instance eating, flying, chasing congeners in a great confusion on ivory nut palm inflorescences. Recorded feeding also in the following plants: *Cocos nucifera* (and gleans invertebrates in dead dry leaves), *Morinda citrifolia*, *Pritchardia pacifica*, *Spathodea campanulata*, the very common introduced flower *Stachytarpheta* (cf. *cayennensis*, ex. *urticaefolia*), and in cultivated *Hibiscus* sp. (piercing the basis of the flower from behind). Breeding data are scarce with occupied nests in October–November, and feeding of fledglings in May, September–November [Gardiner (in Gadow 1898); Clunie 1985; Zug *et al.* 1988; this work]. Gardiner (in Gadow 1898) gave an accurate description of the nest placed “*in any fork formed by the twigs of the hifo tree (*Callophyllum inophyllum*). The nest is made of grass and rather deep. The eggs, numbering from three to five, are white, with a few red spots, very large for the size of the bird*”.

Polynesian triller (*Lalage maculosa rotumae**)
Breeder. The Polynesian triller includes 16 subspecies distributed in Temotu (South Solomon), Vanuatu, Fiji and surrounding islands (Rotuma and Futuna), Tonga, Samoa, and Niue. The endemic subspecies *rotumae* is larger than *woodi* from Northern Fiji, with a more tawny coloration of the tips of the back and rump feathers and on the underparts (Mayr & Ripley 1941). It occupies both the coastland and the inland, in all types of habitats (coconut groves, cultivations, villages, secondary forests, open coastal forests), even along the airstrip when the grass has been freshly cut. It is less common in secondary forests when the cover is too dense, whereas it is abundant at the edge of forests and in open habitats (generally cultivations). Recorded on ‘Afgaha (2018) and Uea (1991) and it probably occupies other islets. On mainland, density is high with several individuals/ha. Population number is similar to that of the myzomela, i.e. 10,000–19,999 individuals. Relatively tame in villages, some birds do not hesitate to visit vegetables and fruits baskets in the market at Ahau, in the middle of people. Breeding period spreads at least from September to December, but is probably longer, starting in August or earlier.

Fiji shrikebill (*Clytorhynchus vitiensis wiglesworthi**)
Breeder. This shrikebill is present on most of the Fijian archipelago and surroundings islands (Futuna, Rotuma), in Tonga, and Samoa, with 12 recognized subspecies. The endemic subspecies *wiglesworthi* is more rufous and darker on face than *buensis* from Northern Fiji (Mayr 1933), but the differences between populations are weak. Forest dweller found all over the mainland, although markedly less common than the three other endemic Rotuman passerines. In 1991 it was much commoner on Uea than on mainland, and a singer was heard on ‘Afgaha in 2018. Relatively more abundant in dense secondary forests inland, where it was often the commonest passerine. However, it occupies all woody groves, even of very small range (e.g. Malvaceae trees), in farmlands, villages, and on the coast. Population number estimated in 2018 at a few thousand individuals. However, the destruction of several hectares of forest along the airstrip, in addition to the cutting of the larger trees at Elsio and Pepheua, has clearly reduced available habitat. Breeding habits remain poorly known; its nest and eggs were never described. In 2018, we captured several females with brood-patches, and we found a dead chick (less than a week old) fallen from a nest on 1 October, suggesting that the breeding season had begun. Most birds collected in May 1925 by Correia were “*in badly worn plumage or molting*” (Mayr 1933), thus past the breeding season.

Polynesian starling (*Aplonis tabuensis rotumae**)
Breeder. The Polynesian starling has 12 subspecies, distributed on Temotu (South Solomon), Fiji Is. and surrounding islands [Futuna, Uea (Wallis), and Rotuma], Tonga, Samoa, and Niue. The endemic subspecies *rotumae* has paler underparts than *vitiensis* (Viti Levu), with broad greyish margins on back and rump feathers (Mayr 1942). Present all over the island, and probably on all islets (seen on Kalvaka, ‘Afgaha, Uea, and in flight toward the islets off Oinafa). Abundance varies greatly among habitats. Very common in cultivations and around

villages where food is plentiful (up to ten birds/ha), but less abundant in coconut groves and in very low density in dense secondary forests. Population number similar to the Rotuma myzomela and Polynesian triller, i.e. 10,000–19,999 individuals. Recorded feeding on the following plants or fruits: *Carica papaya*, *Flacourtia rukam*, ripe mangoes (*Mangifera indica*) on the ground, *Micromelum minutum*, bananas (*Musa*), *Psidium guajava*, and according to Zug *et al.* (1988) chili peppers (*Piper* sp.). No observations were obtained in secondary forests where they probably eat berries and fruits of the native trees. We also observed a starling attempting to open a hermit-crab with its bill, on rocks off the shore, and we found broken shells of small terrestrial molluscs in the forests, possibly predated by starlings. In September and October, we caught birds showing brood-patches, fledglings, and one dead chick fallen from its nest, suggesting that the breeding season had begun. Clunie's (1985) observations of birds carrying food or nest materials indicated that it extended at least to December.

Common myna (*Acridotheres tristis*)
Introduced. It arrived on Rotuma, ship-assisted, at the end of 2017 or early 2018 and it settled first around the jetty in Oinafa. In September–October 2018, we found five isolated pairs in the following coastal localities: Oinafa (near the jetty), Paptea, Marama, Noa'tau, and 'Utu. The myna did not disperse west of Oinafa in the North, suggesting that the large stand of dense secondary forests between the jetty and Lopta constituted a barrier. It might however continue its spread west of 'Utu in the South, where such forests are not present. Not recorded inland. Two pairs were probably visiting nesting sites, and two others were feeding chicks at nest. They were seen foraging for invertebrates in grasslands. The myna's future expansion on the island could likely be possibly to the detriment of the endemic passerines, in particular of the Rotuma myzomela, which occupies the same habitat.

Sheath-tailed bat (*Emballonura semicaudata*)
Extirpated. First recorded by Correia in 1925, in the thousands. Clunie (1985) described movements in the evening of thousands of bats in the caves of Itu'muta, noting that they were in far larger numbers than was usual in Fiji. In 1991, it was still seen every evening and some were found roosting in an overhang. But in September–October 2018, we did not observe any bats or caught any in mist-nets, nor did we obtain any information suggesting their presence. Our visits to four caves at Itu'muta (1 in Lulu, 2 in Losa, 1 in Fapufa) were unsuccessful. We questioned numerous villagers (in Itu'muta, Noa'tau, Oinafa, Lopta, Ahau) and found that people younger than 30 years old did not know the bat, and older people only remember seeing them when they were young, but none for at least a decade. We concluded that the bats are probably extirpated on Rotuma, but the causes of their disappearance remain unknown. Predation by cats or other introduced animals can be excluded. Primary forests have been transformed to cultivations and secondary forests long since the colonization by Polynesians, with no major changes since the 1990's. Except for the cave at Losa that is used by people to bath in a little fresh water basin, the caves are seldom visited, although during WW II some were used as shelters. Pesticides on the other hand cannot be excluded: they were apparently used in great quantity still in the early 2000s (McKay 2007), and then banished only recently by all islanders. The introduction of a new pathogen agent could also be a possible explanation. Despite its large range, the species has declined in all archipelagos from Micronesia to Western Polynesia since the beginning of the 20th Century (Lemke 1986; Helgen & Flannery 2002; Tarburton 2002; Palmeirim *et al.* 2007; Wiles *et al.* 2011; Anon. D). The species is still included in the category "endangered" by the IUCN (Bonaccorso & Allison 2008), but probably best considered now "critically endangered".

DISCUSSION

Because of the small size of the islands and the relatively easy accessibility of most habitats, the record of the breeding landbirds is quite straightforward. On the other hand, the nocturnal Procellariiformes remain under-investigated and further investigations will be necessary, particularly on the smaller islets. The landbird species found today on Rotuma are generalists that live preferentially in the cultivation areas rather than in the dense secondary forests. It is possible that the more specialized species vanished after the arrival of humans, because of habitat changes and hunting. Rotuma's current avifauna can be compared to that of Futuna and Alofi, two islands 545 km east, which are comparatively small and isolated in the Pacific Ocean (Fig. 1). These two islands are only separated by a 1.7 km strait that some birds cross regularly (Thibault *et al.* 2015). Both avifaunas are similar at 65% (Table 1), having in common widespread Western Polynesian species that are successful in colonizing small and remote islands [the "supertramp" of Diamond (1974)]. The honeyeaters are the exception, the two island groups having two different species of Meliphagidae with similar ecological niches; the Rotuma myzomela on Rotuma and the Polynesian wattled honeyeater (*Foulehaio carunculatus*) on Futuna and Alofi. The absence of some groups of birds on Rotuma could be attributed to 1) extinction for the Tongan ground dove (*Alopecoenas stairi*), the spotless crake (*Zapornia tabuensis*), the collared kingfisher (*Todiramphus*

Table 1. Comparison of the landbirds of Futuna and Rotuma. † indicates extinct populations.

	Futuna-Alofi	**Rotuma and islets**
Area (km²)	46 + 32	47
Altitude (m a.s.l.)	524	260
Species		
Metallic pigeon †		X
Pacific imperial pigeon	X	X
Crimson-crowned fruit dove	X	X
Buff-banded rail	X	X
Australasian swamphen	X	X
Pacific reef egret	X	X
Eastern barn owl	X	X
Meliphagidae sp.	X	X
Polynesian triller	X	X
Fiji shrikebill	X	X
Polynesian starling	X	X
Pacific black duck	X	
Spotless crake	X	
White-rumped swiftlet	X	
Collared kingfisher	X	
Blue-crowned lorikeet	X	
Tongan ground dove †	X	

chloris), and the blue-crowned lorikeet (*Vini australis*); 2) the absence of wetlands for the Pacific black duck (*Anas superciliosa*); and 3) competition for roosting in caves for the white-rumped swiftlet (*Aerodramus spodiopygius*) on Futuna *vs*. the sheath-tailed bat on Rotuma.

The high density of the Rotuman landbirds is unusual today among tropical Pacific islands. The Pacific imperial pigeon is suspected to be in decline on several Pacific islands because of habitat destruction and unsustainable levels of exploitation (see for instance Powlesland *et al.* 2008 for Tonga, Thibault *et al*. 2015 for Futuna). The Fiji shrikebill disappeared from several islands of its range: Mamanuca and Yasawa groups in Fiji (Masibalavu & Dutson 2006; Gregory 2018), and Tau in American Samoa (Gregory 2018); in Tonga its range has contracted significantly due to deforestation, understorey clearance by pigs and goats, and predation by cats and rats (Gregory 2018). Finally, the Polynesian triller, common on Rotuma, is rare and localized on Futuna and Alofi (Thibault *et al.* 2015). For a long time, Rotuma was relatively protected by its remoteness and by the absence of a wharf, but recently two alien species managed to reach the island: the common myna in 2017 and the cane toad (*Rhinella marina*) in 2018 (Cibois & Thibault 2019). The project to enlarge the jetty for allowing the docking of cargo-ships will lead to an increase of the number of containers, and in parallel to a higher risk of introductions. The small Indian mongoose (*Herpestes auropunctatus*) arrived at Tonga inside such containers (BirdLife 2016). A similar introduction to Rotuma is possible, and the risk of shipping black rats (*Rattus rattus*), not recorded yet on Rotuma, is even higher. Thus, the vigilance of the Biosecurity Authority of Fiji in controlling containers and cargo-ships, both at their departure from Suva and at their arrival to Rotuma, will be crucial for the protection of the native biodiversity.

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Vagrant and extra-limital bird records accepted by the Birds New Zealand Records Appraisal Committee 2017–2018

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Abstract: We report Records Appraisal Committee (RAC) decisions regarding Unusual Bird Reports received between 1 January 2017 and 31 December 2018. Among the 160 submissions accepted by the RAC were the first New Zealand records of Macquarie Island shag (*Leucocarbo purpurascens*) and Cox's sandpiper (*Calidris x paramelanotus*), and the first accepted at-sea sightings of blue petrel (*Halobaena caerulea*), Salvin's prion (*Pachyptila salvini*), Antarctic prion (*P. desolata*), and thin-billed prion (*P. belcheri*) from New Zealand coastal waters. We also report the second accepted breeding record (and first successful breeding) for glossy ibis (*Plegadis falcinellus*), and the second accepted records of red-footed booby (*Sula sula*) and laughing gull (*Leucophaeus atricilla*). Other notable records included the first record of nankeen kestrel (*Falco cenchroides*) from Campbell Island, and at least 5 northern shovelers (*Anas clypeata*) simultaneously present in June 2018.

Miskelly, C.M.; Crossland, A.C.; Saville, I.; Southey, I.; Tennyson, A.J.D.; Bell, E.A. 2019. Vagrant and extra-limital bird records accepted by the Birds New Zealand Records Appraisal Committee 2017–2018. *Notornis 66(3)*: 150–163.

Key words: Cox's sandpiper, extra-limital, first record, Macquarie Island shag, 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* or *New Zealand Birds*, or in books and websites published by Birds NZ.

We here report RAC decisions made on Unusual Bird Reports (UBRs) received between 1 January 2017 and 31 December 2018, following on from the last report of the RAC (Miskelly *et al*. 2017). These

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include a submission based on historic records 118 years old, but submitted only during the current reporting period.

Results of RAC decisions are posted on the Unusual Bird Report website (http://rare.birds.org.nz/) every 2 months. The website was launched in mid-2016, and 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 Unusual Bird Report received is given a number whereby the first 4 digits represent the year the record was received and the last 3 digits the chronological sequence of receipt within that year. These reference numbers are given for each record below. Nomenclature and taxonomic sequence follow Gill *et al.* (2010), apart from where we follow Heidrich *et al.* (1998) in placing large shearwaters in the genus *Ardenna,* and Pons *et al.* (2005) in using the genus name *Leucophaeus* for laughing gull (*L. atricilla)*. Where images of birds reported here have been published on New Zealand Birds Online (NZBO, www.nzbirdsonline.org.nz, viewed 8 Jun 2019) this is mentioned in the text.

The RAC convenor maintains a database of verified sightings of vagrant birds in New Zealand. Information from this database is presented below (sourced as "C.M. Miskelly *unpubl. data*") if it conflicts with or augments information from published sources. For significant sightings (e.g. 1st or 2nd sightings for the country), we encourage the observers who first found or identified the bird(s) to submit an article for publication in *Notornis*.

DECISIONS ON SUBMITTED SIGHTINGS

Accepted records of vagrant and rare migrant species to New Zealand

Chestnut-breasted shelduck (*Tadorna tadornoides*)
An immature female at Miranda stilt pools, Firth of Thames, on 14 May 2017 (Russell Cannings; UBR 2017/039). A female at Tip Lagoon, Invercargill, on 1 Nov 2017 (Tim Barnard, Neil Robertson, & Phil Rhodes; UBR 2017/082), with 2 females at nearby New River Estuary on 25 Mar 2018 (Matthias Dehling; UBR 2018/039).

There are about 33 accepted records since 1973 (Heather 1987; C.M. Miskelly *unpubl. data*). Apart from records of single birds from Auckland and the Kapiti coast, the 4 other previous records (of up to 9 birds each) since 2014 were from Canterbury (Miskelly *et al.* 2015, 2017).

Northern shoveler (*Anas clypeata*)
All records were of males in full or partial breeding plumage. One at Kaituna Lagoon, Lake Ellesmere on 17 Oct 2017 (Eleanor Gunby & Sandra Wallace; UBR 2018/069); one at Tip Lagoon, Invercargill, on 23 Oct 2017, with 2 there on 28 Oct 2017 (Richard Schofield + 7 others; UBR 2017/079; image on NZBO). One at Miranda stilt pools, Firth of Thames, on 19 May 2018 (Russell Cannings + 5 others; UBR 2018/054), with 2 off the Miranda shellbanks on 17 Jun 2018 (Paul Godolphin & Grahame Brind; UBR 2018/068). One at Nelson wastewater treatment plant on 16 Jun, 5 Jul, and 16 Oct 2018 (Nikki McArthur, Rebecca Bowater, and others; UBRs 2018/061, 061A & 104; 6 images on NZBO). One at Kaitorete Spit, Lake Ellesmere, on 17 Jun and 5 Nov 2018 (Andrew Crossland; UBRs 2018/067 & 111), with 1 on the opposite side of Lake Ellesmere at the same time on 17 June (Matthew Rose + 7 others; UBR 2018/090). One at Porangahau Estuary, Hawke's Bay on 23 Jun 2018 (Colin Shore & Joanna McVeagh; UBR 2018/063).

The timing of these sightings at widely scattered locations indicate that at least 5 northern shovelers were present in New Zealand during 16–17 Jun 2018. This influx was the most notable vagrant bird incursion during 2017–18. Before this period there were 9 accepted records of northern shoveler from New Zealand, and never more than a single record (of up to 2 birds) per annum (Gill *et al.* 2010, and C.M. Miskelly *unpubl. data*).

Hoary-headed grebe (*Poliocephalus poliocephalus*)
One at Bromley oxidation ponds, Christchurch, on 20 May 2015 (Sandra Wallace + 3 others; UBR 2018/064). One at Lake Elterwater, Marlborough, on 12 Jan 2018 (Peter & Charmaine Field; UBR 2018/005), with 11 birds (4 adults and 7 juveniles) there on 27 Jan 2018 (Matthias Dehling and others; UBR 2018/028). Two at Lake Ellesmere on 17 Jun 2018 (Andrew Crossland & Phil Crutchley; UBR 2018/121).

At least 2 pairs of hoary-headed grebes bred in Southland in the late 1970s (Jardine & Miskelly 2017). No records of hoary-headed grebes were received from New Zealand from 1991 until 2012 (Gill *et al.* 2010; Miskelly *et al.* 2013) but they have been recorded from four sites since then. They were first reported at Lake Elterwater in August 2014 (3 birds; Miskelly *et al.* 2015), and breeding has now been confirmed. There are 7 images taken at Lake Elterwater in September 2018 on NZBO.

King penguin (*Aptenodytes patagonicus*)
One at Barrytown Beach, West Coast, between 26 Jan and 3 Feb 2005 (Andrew Crossland and others;

UBR 2018/118). One at Taieri River mouth, Otago, on 30 Dec 2017 (Dave Irving; UBR 2018/055). These are the 4th and 6th accepted records from the South Island (Miskelly *et al.* 2017).

Royal penguin (*Eudyptes schlegeli*)

One at Boulder Beach, Otago Peninsula on 20 Jan 2017 (Ben Smith; UBR 2017/033) is the 11th accepted record from the South Island, and the first since 2006 (Gill *et al.* 2010).

Indian Ocean yellow-nosed mollymawk (*Thalassarche carteri*)

One off Kaikoura on 27 Jul 2007 (Richard Schofield & Gary Melville; UBR 2017/075) and 1 offshore from Golden Bay on 26 Feb 2017 (Steve Wood & Rob Schuckard; UBR 2017/047) were the 2nd and 4th reported sightings of this species from coastal waters near the New Zealand mainland since a pair was reported to be nesting on The Pyramid, Chatham Islands, in 1998–2000 (Medway 2002; Miskelly *et al.* 2006).

Shy mollymawk (*Thalassarche cauta cauta*)

An adult off Stewart Island on 17 Feb 2017 (Matthias Dehling; UBR 2017/027; image on NZBO) was the 3rd accepted record of this Australian subspecies in New Zealand, and the 2nd record of a live bird (Medway 2003; Miskelly *et al.* 2017).

Blue petrel (*Halobaena caerulea*)

One off Otago Peninsula on 14 Jul 2017 (Matthias Dehling; UBR 2017/064; image on NZBO) and 1 east of the Poor Knights Islands on 7 Jul 2018 (Oscar Thomas + 5 others; UBR 2018/072; image on NZBO) were the 1st and 2nd accepted at-sea sightings of this species from New Zealand coastal waters. Blue petrels are frequently found dead on New Zealand beaches in winter (e.g. 343 in 1981; Powlesland 1983).

Salvin's prion (*Pachyptila salvini*)

One off Otago Peninsula on 27 Mar 2017 (Matthias Dehling & Graeme Loh; UBR 2017/045; 2 images on NZBO) was the 1st accepted at-sea sighting of this species from New Zealand waters. Salvin's prions are frequently found dead on New Zealand beaches in winter (Powlesland 1989).

Thin-billed prion (*Pachyptila belcheri*)

One off Otago Peninsula on each of 26 Mar and 13 Jul 2018 (Matthias Dehling & Graeme Loh; UBRs 2018/036 & 089), and 1 east of the Poor Knights Islands on 7 Jul 2018 (Matthias Dehling; UBR 2018/088) were the 1st to 3rd accepted at-sea sightings of this species from New Zealand waters. One was also found alive on Ninety Mile Beach, Far North, on 24 Jul 2018 (Les Feasey + 3 others; UBR 2018/096; image on NZBO). Thin-billed prions are frequently found dead on New Zealand beaches in winter (Powlesland 1989).

Figure 1. Pink-footed shearwater off Kaikoura, 12 Feb 2018 (image by Matt Anderson).

Pink-footed shearwater (*Ardenna creatopus*)
One off Kaikoura on 12 Feb 2018 (Gary Melville, Matt Anderson, + 4 others; UBRs 2018/018 & 059; Fig. 1 and image on NZBO) was the 6th accepted New Zealand record of this South American species.

Red-footed booby (*Sula sula*)
One first observed at the Muriwai gannet colony, West Auckland, on 18 Jan 2017 (Blair Outhwaite & Zoe Lilley; UBR 2017/004) stayed until at least 24 Feb 2017 and was observed and photographed by many people (14 images on NZBO; Fig. 2). This was the 2nd record from New Zealand and the 1st from the mainland (Miskelly *et al.* 2017).

The Muriwai bird was a white morph bird with a dark tail, indicating that it was of the eastern tropical Pacific form *S. s. websteri* (Nelson 1978; Harrison 1983; del Hoyo *et al.* 1992).

Brown booby (*Sula leucogaster*)
One photographed off Kapiti Island on 16 Apr 2017 (Geoff de Lisle, Dallas Bishop, & Peter Hodge; UBR 2017/034). Brown boobies probably reach New Zealand every year, with most records from the northern North Island (Gill *et al.* 2010; Miskelly *et al.* 2017).

Macquarie Island shag (*Leucocarbo purpurascens*)
An adult and an immature collected at the Auckland Islands on 4 and 9 Jul 1901 by Commander John Rolleston of HMS *Archer* were correctly identified at the time (Ogilvie-Grant 1905, where they are listed as '*Phalacrocorax traversi*', which is a junior synonym of *Leucocarbo purpurascens*) and remain in the care of the Natural History Museum, Tring, United Kingdom. The log of the Archer and contemporary newspaper articles reveal that the vessel never visited Macquarie Island, and was at the Auckland Islands on the dates that the birds were collected (evidence presented as UBR 2018/115, and see Miskelly & Cooper accepted ms). The specimens were overlooked by all four editions of the checklist of the birds of New Zealand (Fleming 1953; Kinsky 1970; Turbott 1990; Gill *et al.* 2010), and so this is an addition to the New Zealand list.

Figure 2. Red-footed booby at Muriwai gannet colony, West Auckland, 28 Jan 2017 (image by Paul Kettel).

Lesser frigatebird (*Fregata ariel*)
One west of Tiritiri Matangi Island, Hauraki Gulf, on 7 Jan 2018 (Matthew Crawford & Qin Huang; UBR 2018/010). There have been about 40 previous New Zealand records (Gill *et al.* 2010, and C.M. Miskelly *unpubl. data*), although this was the 1st since 2011 (Miskelly *et al.* 2013).

Frigatebird sp. (*Fregata* sp.)
A frigatebird of uncertain specific identity (probably a lesser frigatebird) was seen at Takou Bay, Kaeo, Far North, on 19 Feb 2017 (Ian Lawson, Jason & Karen McCondack; UBR 2017/020).

Little egret (*Egretta garzetta*)
One at Lake Ellesmere on 27 Jun 1987 (George Watola, Paul Sagar, & others; UBR 2017/077), 1 at Lake Forsyth, Canterbury, on 30 Jun 2013 and 15 Oct 2016 (Nick Allen, Peter Reese, & Trevor Raines; UBRs 2017/028 & 016), 1 at Manawatu estuary on 22 Apr 2017 and 31 May and 26 Oct 2018 (Peter Hodge, Imogen Warren, & Lisa Fraser; UBRs 2017/036, 2018/058 & 110, 3 images on NZBO), one at Unahi, Northland, on 10 Jul 2017 (Scott Brooks & family; UBR 2017/057), with 3 there on 11 Aug 2017 (Les Feasey & Kevin Matthews; UBR 2018/095), 3 at Kaimaumau, Northland, on 2 Aug 2018 (Les Feasey; UBR 2018/094, image on NZBO).

Up to 5 little egrets are present in New Zealand most years (Miskelly *et al.* 2013, 2017).

Nankeen kestrel (*Falco cenchroides*)
One on Campbell Island on 9 and 10 May and 16 Aug 1942 (Jack Sorensen & Bill McDougall via Colin Miskelly; UBR 2018/102) was the 1st record from any of New Zealand's subantarctic islands. One on Te Werahi Lagoon track, near Cape Reinga, on 8 Jun 2018 (Graeme Loh & Sue Maturin; UBR 2018/066). The nankeen kestrel is an infrequent straggler to New Zealand (Gill *et al.* 2010).

Sanderling (*Calidris alba*)
One on Enderby Island, Auckland Islands, on 5 Feb 2008 (Richard & Suzanne Schofield & others; UBR 2018/106) was the 1st record from any of New Zealand's subantarctic islands (Miskelly *et al.* accepted ms). One at Lake Ellesmere, on 21 Feb 2015, 17 Dec 2016, 23 and 29 Jan and 26 Sep

2017, and 17 Feb 2018 (Philip Crutchley, Michael Ashbee, Matthias Dehling, Kieran Rowe, & Richard Schofield + 4 others; UBRs 2017/058, 049 & 090, & 2018/049), 1 at Ashley-Saltwater Creek estuary, Canterbury, on 15 Dec 2018 (Andrew Crossland; UBR 2018/119).

One or 2 sanderlings reach New Zealand most years (Saunders 2015; Miskelly *et al.* 2017).

Cox's sandpiper (*Calidris x paramelanotus*)
One at Embankment Road, Lake Ellesmere, on 28 Nov 2016 (Eleanor Gunby, Sandra Wallace, & Mike Ashbee; UBR 2017/013), was the 1st record from New Zealand of this enigmatic sandpiper (a stereotyped hybrid between a male pectoral sandpiper *C. melanotus* and a female curlew sandpiper *C. ferruginea*; Christidis *et al.* 1996; Gunby 2018). Four images on NZBO and 2 in Gunby (2018).

Little whimbrel (*Numenius minutus*)
One at Lake Ellesmere, on 1 Dec 1985 to April 1986, with 2 birds present for part of this period (Andrew Crossland + 7 others; UBR 2018/120). One at Miranda, Firth of Thames on 15 Jan 2018 (Russell Cannings + 13 others; UBR 2018/007, 2 images on NZBO). At least 1 little whimbrel reaches New Zealand most years (Gill *et al.* 2010; Miskelly *et al.* 2017).

Grey-tailed tattler (*Tringa brevipes*)
One at Waitangi West Beach, Chatham Island, on 18 Feb 2017 (Tansy Bliss & Johannes Chambon; UBR 2017/018) was the 4th record from the Chatham Islands (Freeman 1994; Miskelly *et al.* 2013).

Wilson's phalarope (*Phalaropus tricolor*)
One between Whakaki and Te Paeroa Lagoon, Wairoa, on 18 Mar 2017 (Russell Cannings; UBR 2017/052) was the 5th record from New Zealand, but was likely to have been the same bird that was present at Ahuriri estuary, Napier, from November 2016 to late January 2017 (Miskelly *et al.* 2017).

Grey plover (*Pluvialis squatarola*)
One at Miranda, Firth of Thames, on 17 Jan 2018 (David Melville + 14 others; UBR 2018/009). Grey plovers were reported annually from 2001 to 2005; this is the 3rd record since then (Miskelly *et al.* 2013, 2015, 2017), but postings on BirdingNZ.net suggest that this species is under-reported to the RAC. They were not a reportable species before 2001, with up to 12 birds reported per annum (Saunders 2013).

Red-capped plover (*Charadrius ruficapillus*)
One at Miranda, Firth of Thames, on 9 Jan 2018 (Paul Godolphin + 3 others; UBR 2018/004) was the 1st recorded from New Zealand since 1981 (Lake Ellesmere; C.M. Miskelly *unpubl. data*). Red-capped plovers were regularly reported, and occasionally bred, in North Canterbury between 1947 and 1981 (Gill *et al.* 2010).

South Polar skua (*Catharacta maccormicki*)
One off Otago Peninsula on 27 Mar 2017 (Matthias Dehling; UBR 2017/046) was the 18th accepted record from New Zealand (Miskelly *et al.* 2015).

Long-tailed skua (*Stercorarius longicaudus*)
One off Nelson Boulder Bank on 19 Feb 2017 (Steve Wood; UBR 2017/048). Long-tailed skuas are scarce annual migrants to New Zealand, with more than 27 accepted records, including at least 17 birds in 1983 (Melville 1985; Miskelly *et al.* 2017).

Laughing gull (*Leucophaeus atricilla*)
One in breeding plumage photographed 3 km east of Opotiki on 14 Dec 2017 (John & Sue McLennan; UBR 2017/095, image on NZBO) was most likely the same bird that was present around Opotiki the previous summer (i.e. New Zealand's 1st laughing gull; Miskelly *et al.* 2017).

Gull-billed tern (*Gelochelidon nilotica*)
The most frequently reported unusual bird species during 2017–18. A major influx of gull-billed terns began in 2011 (Miskelly *et al.* 2013), and a few birds have apparently remained in the country since. All 2017–18 reports were from the South Island: 2 at Awarua Bay, Southland, on 19 Jan 2016 and 22 Apr, and 5 Aug 2017 (Lindy Schneider, Glenda Rees, & Phil Rhodes; UBRs 2017/030, 037 & 074, 2 images on NZBO); 1 at Motueka sandspit on 13 Jan 2017, and 31 Jan and 5 Feb 2018 (Matthias Dehling, Glenn Kincaid, & David Melville; UBRs 2017/006 and 2018/014 & 015); 2 at Bromley oxidation ponds, Christchurch, on 18 Apr 2017 (Grahame Bell; UBR 2017/041); 1 at Lake Forsyth, Canterbury, on 31 May 2017 and 7 May 2018 (Andrew Crossland; UBRs 2017/042 & 2018/117); 3 (possibly 4) at Lake Ellesmere on 17 Jun 2017, with 1 there on 4 Apr 2018 (Eleanor Gunby, Kenny Rose, & Andrew Crossland + 4 others; UBRs 2017/053 & 094 and 2018/024); and 1 at Bell Island shellbank, Waimea Inlet, Tasman District, on 24 Nov 2017 and 28 Jan 2018 (David Melville + 3 others; UBRs 2017/091 & 2018/011).

Gull-billed terns were frequently reported since the 1970s, with individuals apparently staying in one location for up to 14 years (Southey 2017).

White-winged black tern (*Chlidonias leucopterus*)
One at Nelson Boulder Bank on 5 Oct 2009, up to 5 birds there 6 Dec 2014 to 31 Dec 2015, and 26 Jan 2017 (Peter & Charmaine Field, & Ian Faulkner; UBRs 2017/071, 070 & 073, 6 images on NZBO), and 3 birds (1 in breeding plumage) at Motueka River bridge on 7 May 2016, with 2 there on 3 Aug 2016 (Peter & Charmaine Field; UBR 2017/072).

White-winged terns are not reportable in the eastern South Island. At least 10 were present on Canterbury coastal wetlands and braided rivers during 2018 (A. Crossland *unpubl. data*) with 6 birds (including 3 in breeding plumage counted on a census of the lower Waimakariri River on 1 Nov 2018 (Popenhagen 2019). Elsewhere in New Zealand a few white-winged black terns are recorded each year (Gill *et al.* 2010).

Whiskered tern (*Chlidonias hybridus*)
One at Tip Lagoon, Invercargill, on 30 Oct 2017 (Paul Jacques & Finlay Cox; UBR 2017/088), 1 at Lake Rotoiti, Rotorua, on 22 Dec 2017 (Les Feasey + 3 others; UBR 2017/097, 3 images on NZBO), and 1 at Tongariro River mouth, Lake Taupo, on 21 Jan 2018 (Russell & Lisa Cannings; UBR 2018/013, 2 images on NZBO). There are 8 previous accepted records from New Zealand (Miskelly *et al.* 2011).

Arctic tern (*Sterna paradisaea*)
One at Ashley estuary, Canterbury, on 30 Nov 2015 (Eleanor Gunby, Sandra Wallace, & Mike Ashbee; UBR 2017/059), one at Horseshoe Bay, Stewart Island, on 20 Nov 2016 (Glenda Rees; UBR 2017/002), 1 at sea east of the Poor Knights Islands on 7 Jul 2018 (Matthias Dehling + 7 others; UBR 2018/085), and 1 at Foxton Beach, Manawatu, on 14 Nov 2018 (Imogen Warren; UBR 2018/113).

The Arctic tern is a passage migrant to New Zealand (Miskelly *et al.* 2008; Gill *et al.* 2010), with most birds presumably passing offshore.

Common tern (*Sterna hirundo*)
One at Foxton Beach, Manawatu, on 20 Nov 2016, 31 Oct 2017, and 23 Feb, 4 Mar and 14 Nov 2018 (Imogen Warren, Matthias Dehling, & Phil Battley; UBRs 2017/010 & 080, and 2018/027, 021 & 112; 7 images on NZBO, including 3 of a bird in breeding plumage on 4 Mar 2018). One at Waikanae River estuary on 11 Nov 2017 (Alan & Sam Tennyson; UBR 2018/003, image on NZBO), 1 at Waitangi, Hawke's Bay, on 20 Apr 2018 (Wayne & Margaret Twydle; UBR 2018/046), and 1 in breeding plumage at sea off Otago Peninsula on 6 Oct 2018 (Lei Zhu & Hamish Spencer; UBR 2018/124).

There are about 42 accepted records of common terns from New Zealand, with about a quarter of these being from the Manawatu estuary/Foxton Beach (C.M. Miskelly *unpubl. data*).

Oriental cuckoo (*Cuculus optatus*)
One at Greytown, Wairarapa, on 14 Oct 2018 (Kate Clark; UBR 2018/103). There are about 35 previous records from New Zealand (Miskelly *et al.* 2017; C.M. Miskelly *unpubl. data*).

White-throated needletail (*Hirundapus caudacutus*)
One photographed at sea offshore from Gisborne on 9 Jan 2018 (Amanda Dubuque & Rebecca Lindsay via Matthew Harris; UBR 2018/080). White-throated needletails are frequent vagrants to New Zealand (Gill *et al.* 2010).

Australian tree martin (*Petrochelidon nigricans*)
One at Bromley oxidation ponds, Christchurch, on 5 Feb 2017 (Andrew Crossland + 4 others; UBR 2017/043) was the 1st accepted mainland record since 2004 (Scofield 2008). There are about 50 accepted records from New Zealand (C.M. Miskelly *unpubl. data*).

Accepted extra-limital records of New Zealand breeding species

Cape Barren goose (*Cereopsis novaehollandiae*)
One at Waimauku, Auckland, on 28 Jan 2017 (Amy Robertshaw; UBR 2017/012), and 2 at Omata, New Plymouth, on 5 Jul 2018 (Faye, Rose & Kura Crawford; UBR 2018/071). There are at least two small feral populations of Cape Barren geese in New Zealand, and they are widely held by wildfowl enthusiasts (Gill *et al.* 2010).

Australian wood duck (*Chenonetta jubata*)
Eight at Bell Island oxidation ponds, Waimea Inlet, on 28 Jan 2018 (David Melville + 3 others; UBR 2018/012) and 1 at Westdale Road, Tasman, on 2 Aug 2018 (David Melville; UBR 2018/076). Two images taken in the Waimea district in October 2017 and September 2018 are on NZBO.

These birds are part of the small colonising population that has established in the Waimea Inlet catchment since 2014 (Cook *et al.* 2016; Miskelly *et al.* 2017).

New Zealand dabchick (*Poliocephalus rufopectus*)
One or 2 present annually at Nelson oxidation ponds, Wakapuaka, during autumn and winter from 2013 to 2018, with representative UBRs submitted for 26 May – 3 Aug 2013, 27 Apr – 11 Aug 2014 (2 birds

on 17 May, 14 Jun, & 11 Aug 2014), 27 Apr – 4 Jul 2016 (2 birds on 23 May, 6 & 20 Jun, & 4 Jul 2016), 26 Mar – 24 Jun 2017, & 27 Feb – 18 May 2018 (Peter & Charmaine Field + 3 others; UBRs 2017/066 to 069 & 2018/56). A record from June 2015 was reported by Miskelly *et al.* (2017). Two at Lake Killarney, Takaka, on 4 Oct 2017, with 5 there on 27 Aug 2018 (Ken George; UBRs 2018/081 & 081A). Two at Lake Elterwater, Marlborough, on 27 Jan & 17 Feb 2018 (Matthias Dehling; UBR 2018/029).

New Zealand dabchicks are widespread in the North Island and have a small population established in the Nelson and Marlborough regions, with breeding at Lake Killarney reported from 2012 (Petyt 2013), and suspected at Blind River irrigation dam, Seddon, in 2015 (Miskelly *et al.* 2017).

Australasian little grebe (*Tachybaptus novaehollandiae*)
One at St Annes Lagoon, Cheviot, on 26 Apr 2018 (Oscar Thomas & Mike Ashbee; UBR 2018/051) and 1 at Lake Killarney, Takaka, on 28 Jun 2018 (Ken George; UBR 2018/077) were the 1st and 2nd South Island records since 2008 (Miskelly *et al.* 2015). This rare breeding species is now mainly recorded from Northland and Auckland (Miskelly *et al.* 2015; Beauchamp 2019).

Eastern rockhopper penguin (*Eudyptes filholi*)
One moulting at Cape Palliser, Wairarapa, on 30 Jan 2017 (Colin Miskelly & Alan Tennyson + 5 others; UBR 2017/019, 3 images on NZBO) was the 1st record from the North Island, and only the 3rd confirmed record from either of the 2 main islands (C.M. Miskelly *unpubl. data*). Within the New Zealand region, eastern rockhopper penguins breed on Antipodes and Campbell Islands, and the Auckland Islands.

Erect-crested penguin (*Eudyptes sclateri*)
Single birds moulting at Waitangi Beach, Chatham Island, on 24 Jan 2017 (Tansy Bliss; UBR 2017/025), Kaikoura on 29 Jan 2017 (David Seibel & Bob Gress; UBR 2017/017), Mangere Island, Chatham Islands, on 23 Feb 2017 (Tansy Bliss , Johannes Chambon & Gemma Green; UBR 2017/024), and at Akaroa, Canterbury, on 13 Feb 2018 (Rich & Nanette Armstrong; UBR 2018/017).

Erect-crested penguins breed on the Bounty and Antipodes Islands, with at least 1 bird reported moulting on the east coast of the South Island and on the Chatham Islands during January–March each year (Miskelly *et al.* 2006, 2015).

Snares crested penguin (*Eudyptes robustus*)
One on Bench Island, Stewart Island, on 18 Apr 2018 (Ian Southey + 24 others; UBR 2018/047). Two previous records from on or near Stewart Island were listed by Marchant & Higgins (1990), and there are several records of birds moulting along the east coast of the South Island (Miskelly *et al.* 2015).

Yellow-eyed penguin (*Megadyptes antipodes*)
One found dead at Waikawa Stream, Horowhenua, on 26 Apr 2018 (Hugh Robertson; UBR 2018/050) was north of their usual range (Marchant & Higgins 1990).

Grey-headed mollymawk (*Thalassarche chrysostoma*)
One found alive at Te One, Chatham Island, in September 1975 (Neil Hutchison via Colin Miskelly; UBR 2018/020) becomes the 1st of 4 records from the Chatham Islands (Imber 1994; Miskelly *et al.* 2006).

Chatham Island mollymawk (*Thalassarche eremita*)
One off Cape Saunders, Otago, on 16 Oct 2016 (Matthias Dehling; UBR 2017/005, image on NZBO), and 1 off Mahia Peninsula, Hawke Bay, on 22 Oct 2017 (Matthias Dehling + 3 others; UBR 2017/083). There are 4 earlier records from New Zealand (mainland) coastal waters in the RAC database, and at least 10 earlier unreported records (C.M. Miskelly *unpubl. data*).

Chatham Island taiko (*Pterodroma magentae*)
One at sea *c.* 40 km west of the Bounty Islands on 19 Oct 2018 (Paul Sagar; UBR 2018/108) is the 1st accepted record away from the Chatham Islands. Several other reports of Chatham Island taiko seen south-west of the Chatham Islands (including 3 images on NZBO) have yet to be submitted to the RAC.

Kermadec petrel (*Pterodroma neglecta*)
One off Piercy Rock, Bay of Islands, on 24 Dec 2000 (George Watola; UBR 2017/081) becomes the 2nd of 3 accepted records from coastal waters around the New Zealand main islands (Medway 2001; Miskelly *et al.* 2015).

Soft-plumaged petrel (*Pterodroma mollis*)
One east of the Poor Knights Islands on 7 Jul 2018 (Oscar Thomas + 5 others; UBR 2018/073) was the 6th accepted record of a free-flying bird north of Cook Strait (Miskelly *et al.* 2017). The only known breeding site in the New Zealand region is on Antipodes Island (Imber 1983).

White-naped petrel (*Pterodroma cervicalis*)
One at sea south of Kaikoura Peninsula on 5 Jan

2018 (Gary Melville, Amrit Kannan, & Kathleen Jogan; UBR 2018/053) was only the 2nd accepted record south of Gisborne (Tennyson & Lock 1998; Miskelly *et al.* 2013).

Broad-billed prion (*Pachyptila vittata*)
Seven east of the Poor Knights Islands on 7 Jul 2018 (Matthias Dehling + 7 others; UBR 2018/086, 3 images on NZBO) were the northernmost record of live birds at sea. Broad-billed prions are regularly recovered from New Zealand beaches, including in Northland (Powlesland 1989).

Antarctic prion (*Pachyptila desolata*)
One off Cape Saunders, Otago, on 13 Nov 2016 (Matthias Dehling; UBR 2017/007, image on NZBO), 1 off Otago Peninsula on 29 Jun 2017, 4 there on 26 Mar 2018 (Matthias Dehling; UBRs 2017/061 & 2018/030 to 033), and at least 21 east of the Poor Knights Islands on 7 Jul 2018 (Matthias Dehling + 7 others; UBR 2018/084, 4 images on NZBO). These were the 1st to 3rd accepted at-sea sightings of this species from New Zealand coastal waters. Within the region they breed only on the Auckland Islands (Gill *et al.* 2010).

Black petrel (*Procellaria parkinsoni*)
One photographed at sea south of Kaikoura Peninsula on 15 Dec 2017 (Alex Berryman; UBR 2018/057) is the southernmost record of black petrel recognised by the RAC.

Stewart Island shag (*Leucocarbo chalconotus*)
Four records from Ashburton River mouth, South Canterbury, during Mar–Jul 2018: 1 on 26 Mar, 3 on 23 Apr, 9 on 22 Jun, and 3 on 21 Jul (Andrew Crossland; UBRs 2018/023, 048, 062 & 070), and 2 at Timaru Harbour on 21 Jul 2018 (Andrew Crossland; UBR 2018/074). These records add to the growing evidence of this southern New Zealand species ranging into Canterbury waters (i.e. north of the Waitaki River) (Miskelly *et al.* 2011, 2015; Crossland 2012).

Glossy ibis (*Plegadis falcinellus*)
Two fledglings at Blenheim oxidation ponds, near Wairau Lagoon, on 22 Dec 2016 (Matthias Dehling; UBR 2017/008) was the 2nd attempted breeding record and the 1st successful breeding recorded for New Zealand (see Thompson 2015). A record of 3 fledglings at the same Blenheim site in 2015-16 has yet to be submitted to the RAC, but was reported in the March 2016 issue of *Birds New Zealand* (Anon. 2016). In addition to the breeding record, there was 1 at Cape Farewell, Golden Bay, on 16 Dec 2016 (Jo Shepherd; UBR 2017/014), and 1 found dead at Horseshoe Bay, Stewart Island, on 24 Jun 2017 (Matt Jones; UBR 2017/056).

Banded rail (*Gallirallus philippensis*)
One at Pauatahanui Wildlife Reserve, Porirua, Wellington, on 28 Jun and 8 Oct 2018 (Graeme Ludlow, Lisa Fraser & Nan Lynn; UBRs 2018/065 & 100) was an unusual record for the southern North Island (Miskelly *et al.* 2017).

Black stilt (*Himantopus novaezelandiae*)
A colour-banded bird at Te Awaiti Road, Sandy Bay, South Wairarapa, on 2 Dec 2017 (Diana Chetwin; UBR 2018/006) was beyond their usual range (Marchant & Higgins 1993).

New Zealand dotterel (*Charadrius obscurus*)
One at Ashley River estuary, Canterbury, on 5 Dec 2015 and 28 Aug 2016 (Matthias & Maximilian Dehling, and Beverley Alexander; UBRs 2017/087 & 065). A pair on a nest at Waikanae River estuary, Kapiti coast, on 31 Dec 2017 (Alan & Sam Tennyson; UBR 2018/002) was the 1st recorded breeding from the Wellington region.

Subantarctic skua (*Catharacta antarctica*)
One at Kaikoura Peninsula on 8 Apr 2016 (Ric Else; UBR 2017/032), and 1 at sea off Tutukaka, Northland, on 21 Jul 2018 (Matthias Dehling + 10 others; UBR 2018/107). Within the New Zealand region, subantarctic skuas breed on the Chatham Islands and the subantarctic islands, with a few in Fiordland and the Stewart Island region (Higgins & Davies 1996).

Brown noddy (*Anous stolidus*)
At least 20 at the Kermadec Islands (various locations from L'Esperance Rock to and including Raoul Island), 29 Mar – 3 Apr 2016 (Tim Barnard + 4 others; UBR 2017/054) confirms the ongoing presence of this rare New Zealand breeding species at the Kermadec Islands (Veitch *et al.* 2004).

Black noddy (*Anous minutus*)
One at the Chicken Islands, Northland, on 18 Dec 2018 (Edin Whitehead + 3 others; UBR 2018/122). Within the New Zealand region, black noddies breed only on the Kermadec Islands (Veitch *et al.* 2004).

Sooty tern (*Onychoprion fuscata*)
One roosting on Rosemary Rock, Three Kings

Islands, on 23 Nov 2017 (Peter Frost, Neil Fitzgerald, & Richard Robinson; UBR 2018/060). Within the New Zealand region, sooty terns breed only on the Kermadec Islands (Veitch *et al.* 2004).

Antarctic tern (*Sterna vittata*)
One east of Cape Saunders, Otago, on 30 Sep 2018 (Steve Wood, Tim Barnard & others; UBR 2018/105) is the 1st accepted record of this subantarctic species north of Foveaux Strait. A published record from the Chatham Islands was not accepted by the then Rare Birds Committee (Medway 2000; Bell & Bell 2002).

Barbary dove (*Streptopelia risoria*)
One at Seadown, Timaru, on 23 Jan 2017 (Peter Dovey; UBR 2017/011). There have been numerous sightings of Barbary doves around Christchurch, but no others from South Canterbury (eBird, viewed 8 Jun 2019).

Sacred kingfisher (*Todiramphus sanctus*)
One at Kairakau, Chatham Island on 5 Mar 2018 (Colin Miskelly + 5 others; UBR 2018/045) was the 5th record from the Chatham Islands (Miskelly *et al.* 2006).

Common myna (*Acridotheres tristis*)
One at New Brighton, Christchurch, on 9 Apr 2018 (John Stewart; UBR 2018/043), and 2 at Westmorland, Christchurch, on 4 Oct 2018 (Cheryl Skene; UBR 2018/099). Mynas are common in the northern North Island, but are not recognised as having an established population in the South Island (Higgins *et al.* 2006).

Cirl bunting (*Emberiza cirlus*)
One at Church Road, Kaitaia, on 5 Mar 2018 (George & Julia Watola; UBR 2018/022) is the northernmost accepted record of cirl bunting in New Zealand.

Records not accepted
Some of the following records may have been genuine, but were insufficiently documented to be accepted by the Records Appraisal Committee. At least 22 were considered to be misidentifications.

Little spotted kiwi (*Apteryx owenii*)
One reported calling from Wellington (between Karori Cemetery and Skyline Walkway) on 14 Mar 2018 (UBR 2018/041) was considered more likely to be a morepork (*Ninox novaeseelandiae*).

Chukor (*Alectoris chukar*)
One photographed at Coatesville, North Auckland, on 10 Sep 2018 (UBR 2018/091) was identified from images as a red-legged partridge (*A. rufa*).

Chestnut teal (*Anas castanea*)
A teal at Tutaki Road, Palmerston North, on 28 Oct 2016 (UBR 2018/083), and 1 at Little Waihi estuary, Bay of Plenty, on 6 Feb 2017 (UBR 2017/015) were probably chestnut teals.

Northern pintail (*Anas acuta*)
Two reported from Washdyke, Timaru, on 12 Nov 2017 (UBR 2017/089).

Northern shoveler (*Anas clypeata*)
One reported from Kaituna Lagoon, Lake Ellesmere on 17 Oct 2017 (UBR 2017/086). Images showed this bird to be a pale male Australasian shoveler (*A. rhynchotis*); however, a male northern shoveler was seen at the same location on the same date. Multiple observers visited on this date and over subsequent days, noting the presence of more than 10 pale male Australasian shovelers, including this bird.

Western rockhopper penguin (*Eudyptes chrysocome*)
One reported at sea south of Stewart Island on 10 Mar 2018 (UBR 2018/079) was identified from images as a Fiordland crested penguin (*E. pachyrhynchus*).

Erect-crested penguin (*Eudyptes sclateri*)
One reported from Point Kean, Kaikoura Peninsula, on 6 Feb 2013 (UBR 2017/093) was identified from images as a Fiordland crested penguin. One reported at sea south of Stewart Island on 22 Feb 2018 (UBR 2018/078) was identified from a photograph as a Snares crested penguin.

Chatham Island mollymawk (*Thalassarche eremita*)
One reported from Cook Strait on 11 Dec 2015 (UBR 2017/084), and 1 reported off Otago Peninsula on 26 Mar 2018 (UBR 2018/038) were both identified from photographs as Salvin's mollymawks (*T. salvini*).

Antarctic petrel (*Thalassoica antarctica*)
Several birds reported 300 km south-west of the Chatham Islands on 4 Jan 2016 were probably Antarctic petrels (UBR 2017/029).

MacGillivray's prion (*Pachyptila macgillivrayi*)
A prion photographed off Otago Peninsula on 29

Jun 2017 (UBR 2017/061) was assessed to be an Antarctic prion.

Salvin's prion (*Pachyptila salvini*)
Prions reported off Otago Peninsula on 27 Mar and 14 Jul 2017, and 26 Mar 2018 (UBRs 2017/044 & 085 and 2018/037), and up to 5 reported east of the Poor Knights Islands on 7 Jul 2018 (UBR 2018/087) were either Salvin's prions or Antarctic prions.

Antarctic prion (*Pachyptila desolata*)
One reported off Kaikoura Peninsula on 11 Jun 2017 (UBR 2017/051) was identified from images as a fairy prion. Prions reported off Otago Peninsula on 29 Jun and 14 Jul 2017, and 26 Mar 2018 (2 birds) (UBRs 2017/060 & 062 and 2018/034 & 035) were probably Antarctic prions.

Thin-billed prion (*Pachyptila belcheri*)
One reported off Otago Peninsula on 29 Jun 2017 (UBR 2017/063).

Fulmar prion (*Pachyptila crassirostris*)
One reported off Otago Peninsula on 29 Apr 2018 (UBR 2018/052).

Manx shearwater (*Puffinus puffinus*)
A distant shearwater photographed off Gisborne on 21 Oct 2017 (UBR 2018/001) was probably a Manx shearwater.

White-bellied storm petrel (*Fregetta grallaria*)
A storm petrel photographed off Cape Brett, Far North, on 3 Apr 2017 (UBR 2017/050) was too distant to identify conclusively, but was probably a white-bellied storm petrel.

New Zealand king shag (*Leucocarbo carunculatus*)
A *Leucocarbo* shag on Barney's Rock, Kaikoura on 6 Nov 2011 (UBR 2018/075) was considered most likely to be this species, but the information provided was insufficient to rule out pied morph Stewart Island shag.

Little egret (*Egretta garzetta*)
An egret reported at Blueskin Bay, Otago, on 12 Sep 2018 (UBR 2018/092) was probably a little egret.

Reef heron (*Egretta sacra*), white morph
A 'white' heron at Kohukohu wharf, Hokianga Harbour, 9 May 2014 (UBR 2017/096) was identified from photographs as a white-faced heron (*E. novaehollandiae*) with aberrant pale plumage.

Haast's eagle (*Aquila moorei*)
One reported at Bethell's Road, Waitakere Ranges, in 1964 (UBR 2017/023).

Unidentified bird of prey
An unidentified bird of prey at Urupukapuka Island, Bay of Islands, on 5 Jan 2017 (UBR 2017/001) was considered to have been a swamp harrier (*Circus approximans*).

Black kite (*Milvus migrans*)
One reported at Waitiki Landing, Parengarenga Harbour, on 7 Apr 2018 (UBR 2018/042).

Black falcon (*Falco subniger*)
One reported at Diamond Lake, Wanaka, on 22 Jan 2018 (UBR 2018/008).

Nankeen kestrel (*Falco cenchroides*)
One reported in the Hauraki District on 19 Jan 2017 (UBR 2017/022).

Ruff (*Philomachus pugnax*)
One reported at Point Kean, Kaikoura Peninsula, on 27 Mar 2004 (UBR 2017/092).

Subantarctic skua (*Catharacta antarctica*)
A large skua reported off Kaikoura Peninsula on 17 Mar 2018 (UBR 2018/097) was probably a subantarctic skua.

Pacific gull (*Larus pacificus*)
Two reported from Punakaiki on 15 Feb 2018 (UBR 2018/019) were identified from a photograph as southern black-backed gulls (*L. dominicanus*).

White tern (*Gygis alba*)
One reported at Petone Beach on 28 Feb 2017 (UBR 2017/021).

White-winged black tern (*Chlidonias leucopterus*)
One reported from Otago Harbour on 2 Mar 2018 (UBR 2018/044) was identified from photographs as an immature black-fronted tern (*C. albostriatus*).

Antarctic tern (*Sterna vittata*)
One photographed off Otago Peninsula on 6 Oct 2018 (UBR 2018/109) was identified from the images as a common tern, and was resubmitted as UBR 2018/124 (common tern, accepted record).

Common tern (*Sterna hirundo*)
One reported at Motueka on 13 Jan 2017 (UBR 2018/025), single birds reported from Ashley River estuary, Canterbury, on 3 Oct 2017 and 6 Nov 2018 (UBRs 2018/026 & 123), and 1 reported from Foxton Beach on 7 Apr 2018 (UBR 2018/040) were all identified from photographs as immature or non-breeding white-fronted terns.

Crested tern (*Sterna bergii*)
One reported from Waikanae Beach on 7 May 2017 (UBR 2017/040).

Kaka (*Nestor meridionalis*)
One probable record from the Longwood Range, Southland, on 28 Jun 2017 (UBR 2017/055) provided insufficient detail for full acceptance.

White-throated needletail (*Hirundapus caudacutus*)
One reported from Takamatua, Akaroa, on 25 Sep 2018 (UBR 2018/093).

Fork-tailed swift (*Apus pacificus*)
One reported from Hillsborough, Christchurch, on 18 Jul 2017 (UBR 2017/076).

Rock wren (*Xenicus gilviventris*)
One reported at Cape Palliser, Wairarapa coast, on 2 Feb 2017 (UBR 2017/038).

South Island kokako (*Callaeas cinerea*)
One reported on the Heaphy Track, between Lewis and Heaphy huts, on 2 Jan 2017 (UBR 2017/003).

Stitchbird (*Notiomystis cincta*)
One reported on the Hollyford Track, Fiordland, on 1 Mar 2017 (UBR 2017/026) was identified from a photograph as a male tomtit (*Petroica macrocephala*).

Regent bowerbird (*Sericulus chrysocephalus*)
One reported from Welcome Bay, Tauranga, on 23 Apr 2017 (UBR 2017/035) was considered most likely to be a common myna that had lost its head feathers, revealing the yellow skin underneath.

Black currawong (*Strepera fuliginosa*)
One reported from Maraenui, Napier, on 12 Nov 2018 (UBR 2018/114) was identified from a photograph of the hand-held bird as being a soot-stained common myna.

Satin flycatcher (*Myiagra cyanoleuca*)
One reported from the Turanganui River bank, Gisborne, on 23 Aug 2018 (UBR 2018/082) was considered likely to have been a welcome swallow (*Hirundo neoxena*).

Fernbird (*Bowdleria punctata*)
One reported from Flat Point, Wairarapa, on 18 Feb 2018 (UBR 2018/016) was identified from a photograph as a juvenile yellowhammer (*Emberiza citrinella*).

Cirl bunting (*Emberiza cirlus*)
One reported from Kumeu, Auckland, on 28 Apr 2017 (UBR 2017/031). Cirl buntings are not a reportable species in the eastern South Island; however, 1 reported from Lake Hawea, Otago, on 1 Oct 2017 (UBR 2017/078) was identified from a photograph as a female yellowhammer.

Records of species not requiring RAC verification
A Hudsonian godwit (*Limosa haemastica*) was at Matahui Point, near Katikati, Bay of Plenty, on 26 Dec 2016 (UBR 2017/009), a bellbird (*Anthornis melanura*) was at Tapu Bay, Kaiteriteri, Tasman Bay, on 4 Dec 2018 (UBR 2018/116), 2 cirl buntings were at Aniseed Valley, Richmond, Nelson on 2 Oct 2018, with 1 at Angelus Ave, Richmond, on the same date (UBRs 2018/098 & 101).

DISCUSSION

Between January 2017 and December 2018, the Records Appraisal Committee received 221 Unusual Bird Reports. Excluding 5 reports of 'non-reportable' species, 160 of 216 submitted UBRs were accepted (74%). This compares with an acceptance rate of 84% for 506 submissions during April 2008 to December 2016 (Miskelly *et al.* 2011, 2013, 2015, 2017). The number of UBRs received during 2017–18 (9.2 month^{-1}) was considerably higher than the 5.8 month^{-1} received during 2015–16 (Miskelly *et al.* 2017), and the total of 124 submissions in 2018 was the most ever received by the RAC in a calendar year. The lower acceptance rate in 2017–18 was partly due to the large number of misidentified common species reported by inexperienced birders, no doubt facilitated by the ease of online reporting on the publicly accessible Birds NZ website. These records are welcomed, and fortunately the high proportion of photographs submitted aided the correct identification of many of these common species.

The most notable records assessed during 2017–18 were the addition of 2 further taxa to the

New Zealand list (Macquarie Island shag and Cox's sandpiper). The shag record was based on 2 extant specimens collected in 1901 and correctly identified in a publication in 1905 (Ogilvie-Grant 1905; Miskelly & Cooper accepted ms), and it is not known why the record has been overlooked subsequently. This record increases the number of bird species recorded naturally from New Zealand since AD 1800 by 1 to 353 (Miskelly *et al.* 2017; Gill *et al.* 2010). Of these, 15 are considered extinct. In addition, 36 introduced species are currently considered established in the wild in New Zealand, making the current avifauna 374 species (including 26 migrant species and 139 vagrant species).

Cox's sandpiper is a hybrid between two species that regularly reach New Zealand (pectoral sandpiper and curlew sandpiper), therefore the acceptance of this record does not alter the total number of species recorded from New Zealand. Cox's sandpiper received much attention in Australia during the 1980s (e.g. Parker 1982; Cox 1987, 1989). However, interest in the birds waned following genetic confirmation of their hybrid origin (Christidis *et al.* 1996). They are not considered reportable by the Birds Australia Records Committee (https://www.birdlife.org.au/conservation/science/rarities-committee; viewed 29 May 2019), and so the rate at which they occurred or were detected in Australia in recent decades is unknown. The occurrence of a Cox's sandpiper in New Zealand in 2016 is particularly surprising when one of the parent species (curlew sandpiper) has undergone a substantial decline since the 1980s (Dawes 2011; Riegen 2017). However, it is unknown whether declining parent populations would increase the rate of hybridisation (e.g. if there is a shortage of potential mates at a site) or lead to a decreased rate of hybridisation (e.g. if contracting core ranges lead to non-overlapping breeding distributions of the parent species).

New Zealand's 2nd red-footed booby record followed less than a year after the 1st (Miskelly *et al.* 2017), and the single bird involved was much more accessible to birders. The 2017 bird was not only at a much-visited public viewing site (the Muriwai gannet colony), but was consistently present for more than 5 weeks. This resulted in it being one of the most viewed and photographed vagrant birds ever to reach New Zealand, possibly 2nd only to an emperor penguin *Aptenodyptes forsteri* at Pekapeka Beach in 2011 (Miskelly *et al.* 2012). The 2017 bird was also notable in apparently being *Sula sula websteri* from the eastern tropical Pacific, rather than *S. s. rubripes* from Polynesia and northern Queensland, and so represents an example of extreme vagrancy.

The most notable incursion during 2017–18 was the arrival of at least 5 northern shovelers (there were likely to have been more, as only the easily-recognised drakes in nuptial plumage were reported). Birds were 1st reported in October 2017 (at Lake Ellesmere and Invercargill), the incursion peaked in June 2018, and the last reported sighting was at Lake Ellesmere in November 2018. At least 2 birds were reported from South Australia during the same period (Birdlife Australia Rarities Committee Index of Cases, viewed 29 May 2019), and 1 from Norfolk Island in June 2017 (AJDT pers. obs., 6 images on NZBO), and so there is some evidence that the incursion was part of a wider Australasian phenomenon.

Another feature of the 2017–18 reporting period was the 1st accepted at-sea sightings of blue petrel, Salvin's prion, Antarctic petrel, and thin-billed prion from New Zealand coastal waters. All these species are frequently wrecked on New Zealand beaches (Powlesland 1989). The records of live birds at sea is partly due to multiple pelagic birding trips being undertaken in autumn and winter and, particularly, the use of modern photographic equipment to capture high quality images allowing the subsequent identification of difficult species such as prions.

Of the 35 vagrant species accepted by the RAC in 2017–18, 10 species (28.6%) were Holarctic breeding migrants (3 Eurasian, 1 North American, 6 either), 8 species (22.9%) breed in Australia, 5 species (14.3%) were probably from the southern Indian Ocean, 3 species (8.6%) were from south-east Asia, and a further 3 species were from Macquarie Island. Two species (brown booby and lesser frigatebird) were probably from the tropical Pacific. Single species arrived from Antarctica (South Polar skua), Chile (pink-footed shearwater), the eastern tropical Pacific (red-footed booby), and North or Central America (laughing gull). This continues the pattern of Holarctic migratory species, followed by Australian species, being the main sources of vagrant bird records in New Zealand (Miskelly *et al.* 2011, 2013, 2015, 2017).

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SHORT NOTE

Egg-sized rocks found in nests of North Island saddleback (*Philesturnus rufusater*)

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North Island saddleback (tīeke, *Philesturnus rufusater*) were reintroduced to Zealandia sanctuary (Karori, Wellington) in 2002. Zealandia is a 225 ha restoration project surrounded by a fence that successfully excludes introduced mammalian predators, except mice (*Mus musculus*). Thirty-nine tīeke were translocated to Zealandia from Tiritiri Matangi Island, and monitoring during the first breeding season in 2002–2003 indicated that just 18 birds contributed to the founding population (*unpubl. data*). After an initial increase in the number of individuals, the 2004–2005 season began with just 5 pairs, bolstered later in the season by a further 4 pairs from the previous year's offspring. Since 2005 the population has increased significantly with estimates, using a distance sampling approach, at around 200–300 individuals (*unpubl. data*). Tīeke have also been detected on many occasions beyond the predator exclusion fence with some instances of successful nesting and fledging in that wider landscape (K.B. *pers. obs.*).

Despite the increasing population of tīeke at Zealandia in 2018, underlying issues related to inbreeding are of concern. The population has undergone severe population bottlenecks, first with their introduction onto Cuvier Island (29 individuals; Lovegrove 1996), then Tiritiri Matangi Island (24 individuals in 1984; Parker & Laurence 2008), and again with their subsequent reintroduction into Zealandia. The consequences of severe genetic bottlenecks are well documented with potential implications including reduced fitness, evinced by increased rates of hatching failure (Jamieson & Ryan 2000; Briskie & Mackintosh 2004; Mackintosh & Briskie 2005; Boessenkool *et al*. 2007), and reduced survival and recruitment (Amos *et al*. 2001; Kruuk *et al*. 2002).

Zealandia management established a nest monitoring project in 2018/2019 to begin examining the relevance of inbreeding depression, and to explore practicalities of potential genetic top-up methods (e.g. egg swaps; Jones 2004; Jones & Merton 2012). Twelve natural nests were found between October 2018 and February 2019 by staff and volunteers, and life-history parameters including clutch size, hatching success, and fledging success were determined.

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In comparison to previous monitored years, the average clutch size and proportion of nests that successfully fledged chicks was low (Table 1). This could be related to population density, inbreeding effects, or climatic variables, among other possibilities.

Table 1. Comparison of available North Island saddleback (tīeke, *Philesturnus rufusater*) nesting statistics at Zealandia sanctuary (Karori, Wellington) from 2002/03 to 2018/19. Excludes nests where numbers of eggs or chicks hatched are unknown.

Breeding season (October–February)	**No. of pairs monitored**	**No. of nests found**	**Clutch size (mean ± SD)**	**No. of chicks (% hatched)**	**No. of fledglings (% fledged)**	**% eggs fledged**	**% nests with fledging chicks**
2002/3	10	21	2.62 ± 0.65	36 (65.5)	28 (77.8)	50.9	66.7
2003/4	13	29	2.59 ± 0.62	52 (69.3)	42 (80.8)	56.0	72.4
2004/5	8	15	2.46 ± 0.72	25 (65.8)	25 (100)	65.8	80.0
2005/6	10	16	2.30 ± 0.53	18 (51.4)	18 (100)	51.4	56.3
2018/19	11	12	1.83 ± 0.69	10 (45.5)	10 (100)	45.5	50.0

The most unexpected finding in the 20018/19 breeding season was the presence of single small, roughly egg-sized rocks in three nests (25% of 2018/19 nests found; Fig. 1). There were no nearby rockfalls or obvious mechanisms for rocks to fall into the nests accidentally. The eggs from each nest were unbroken alongside the rock, suggesting careful placement of the rock in the nest. One rock was retrieved (from the nest shown in Figure 1b), which weighed 6.5 g. We have no weight measurements of actual tīeke eggs to compare, but the rocks had a similar length and width dimensions as a tīeke egg (29 mm length x 22 mm width; compare with a retrieved rock at 28 mm in length at its longest point and 24 mm in width).

Figure 1. A. Rock in a tīeke nest at Zealandia; B. Location of nest shown in A.; C. view inside another tīeke nest where a rock was found alongside fledglings; D. rock found in nest shown in image C, which weighed 6.5 g.

Two rock nests were abandoned at egg-stage subsequent to discovery. The egg from one of these nests disappeared before it could be retrieved for investigation and the other was infertile. In the third nest, the rock was discovered alongside three chicks, which subsequently fledged.

We were unable to determine how the rocks got into the nests, but suggest that the tīeke placed them there. Human intervention is considered highly unlikely because the nests were difficult to find and off the trails at Zealandia. At 6.5 g, the rock that was retrieved weighed approximately 10% of adult tīeke body weight—we consider it plausible that adult birds could have moved this weight as tīeke are commonly observed forcefully prying into rotten logs and moving items on the ground during routine foraging (K.B. & D.F.S. *pers. obs.*).

To our knowledge the presence of rocks in tīeke nests has not been previously observed, and we could find no record of them being discovered in other New Zealand forest bird nests, or indeed cavity or cup nesting forest birds in other places across the globe. However, it has been observed in many ground-nesting shorebird species such as Canada geese (*Branta canadensis*), gulls (e.g. *Larus occidentalis*), terns (e.g. *Sterna hirunda*), and avocet (e.g. *Recurvirostra americana*) (Conover 1985; Sudgen 1947; Coulter 1980; Langlois *et al*. 2012). Ground nesting common loons (*Gavia immer*) have been observed incubating rocks that have been accidentally used as nesting material (DeStefano *et al*. 2013), although it seems unlikely that tīeke would actively collect rocks while collecting nesting material.

There are other possible reasons for this behaviour. For example, it could be due to the 'mistaken egg hypothesis', where an adult bird mistakes a nearby rock for an egg that has fallen from the nest (Conover 1985). There may also be enhanced thermal regulation for remaining eggs (rocks may hold some heat to be released slowly when the incubating adult is foraging), or there could be some anti-predation adaptation through crypsis confusion for predators. Both enhanced thermal regulation and the use of rocks as an anti-predator mechanism have been observed with piping plovers (*Charadrius melodus*; Mayer *et al*. 2009). If this were the case with tīeke it may be expected that this behaviour could be found in other populations. Alternatively, the behaviour may have no adaptive function or occurs for other unknown reasons. Ultimately, we currently have no way of understanding why this pattern was observed, but should it be recorded in the future it may warrant further investigation.

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SHORT NOTE

The ‘French kiwi’ *Dromiceius novaezelandiae* first recorded and named by R.P. Lesson in the Bay of Islands, April 1824

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The scientific expedition of the French naval corvette *La Coquille* under the command of Louis Isidore Duperrey (1786–1865) circumnavigated the globe during 1822–1825 (Cretalla 2010; Dickinson *et al.* 2015; Lee 2018). Within the extensive collections of botanical, mineralogical, and zoological specimens of the expedition, were at least 254 bird species, some 46 of which were apparently new to science (Cuvier 1825). The overwhelming majority were described and named either by René Primevère Lesson (1794–1849), or by his naval surgeon colleague Prosper Garnot (1794–1838), or by the two as co-authors (Lee & Bruce 2019).

La Coquille called at the Bay of Islands, from 3–17 April 1824. The 2 officers responsible for natural history were the first lieutenant Jules-Sébastien-César Dumont d’Urville (botany and entomology) and Lesson (zoology). Garnot had left the ship in Sydney the previous month because of illness.

Lesson and d’Urville undertook the first biological survey of the Bay of Islands since the visit of James Cook in late 1769. The ornithological records of Cook’s naturalists Banks and Solander were never published and collected specimens were evidently dispersed and lost (Bartle 1993).

Lesson collected, described, and named (along with Garnot) a number of New Zealand birds – many for the first time (Andrews 1986). These include southern royal albatross (*Diomedea epomophora*), North Island kaka (*Nestor meridionalis septentrionalis*), North Island saddleback (*Philesturnus rufusater*), North Island tomtit (*Petroica macrocephala toitoi*), North Island robin (*Petroica longipes*), whitehead (*Mohoua albicilla*), and New Zealand kingfisher (*Todiramphus sanctus vagans*).

Lesson also collected specimens and provided descriptions, including the Māori names for three other New Zealand birds, grey warbler (*Gerygone igata*), North Island fantail (*Rhipidura fuliginosa placabilis*), and North Island fernbird (*Bowdleria punctata vealeae*) and lodged them with the Muséum national d’Histoire naturelle (MNHN) in Paris but did not assign scientific names (Lesson 1825). These were left for later naturalists to name (Lee 2016).

Lesson did publish a description and allocated a scientific name *Dromiceius novaezelandiae* for another New Zealand bird, the kiwi, introducing the indigenous name ‘kivi-kivi’ (kiwi kiwi) to ornithology (Mathews 1935). This appears to have been of the Northland taxon of the North Island brown kiwi (*Apteryx mantelli*). However, despite Lesson’s prior publications (1828, 1829 [in Duperrey], 1830, 1838, 1839, 1844), and his name *Dromiceius novaezelandiae* being cited under the entry “Apteryx” in contemporary encyclopaediae (*cf.* Anon. 1838: 352; Heck 1838: 339; Glaire & Walsh 1840: 581) and by Gray in his *A List of the Genera of Birds…* (1840: 63), Lesson’s name was overlooked when the North Island brown kiwi species was later named by Bartlett (1852).

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Lesson's description and name were based on a section of skin, the feathers of which were intended to be woven into a cloak, kākahu, more precisely kahu kiwi (Harwood 2011), shown to him by Māori at the Bay of Islands. During this time the ship was moored at the entrance to Manawaora Bay, near the Russell peninsula, today the site of a remnant Northland brown kiwi population (Craig *et al.* 2010; Lee & Bruce 2019).

Lesson was told that the bird from which the skin was taken was flightless and common in the forest where it was hunted with dogs. Unaware of Shaw (1813), Lesson deduced this bird to be a new and smaller species of the emu that he had seen in New South Wales a few weeks previously and which he recorded in his *Manuel d'Ornithologie* (Lesson 1828: 210) as "L'ÉMOU PAREMBANG *dromiceius Novæ-Hollandiæ. Casuarius Novæ-Hollandiæ*, Lath", followed immediately by:

"EMOU KIVIKIVI, *dromiceius Novæ-Zelandiæ*. Less." *"Cet émou est de moitié plus petit que le précédent ; son plumage est grisâtre, suivant ce que me dirent les naturels, car je n'en ai vu qu'une peau à moitié détruite et informe. Les habitents en estiment la chair et le chassent avec des chiens. Ils le nomment kivi-kivi. Il est très commun dans les forêts de la Nouvelle–Zélande*."

[In translation: 'This emu is half the size of the preceding species [*dromiceius Novae-Hollandiae*'; now *Dromaius novaehollandiae*]; its plumage is greyish, following what the natives said to me, for I have seen only a half-destroyed and shapeless skin. The inhabitants esteem the flesh and hunt it with dogs. They call it kivi-kivi. It is very common in the forests of New Zealand.'] Given the little he had to go on Lesson's deduction was impressive.

It was only after the publication of his *Manuel* in 1828 that Lesson became aware of the *Apteryx* first announced by Shaw (1813). After this Lesson always connected his discovery with Shaw's description (Lee & Bruce 2019). This he cited in his next publication, a livraison from part 2 of the *Zoologie* volume 1 of the voyage (Lesson in Duperrey 1829: 418). Translated, this states: 'The natives often spoke to us of a bird without wings, of which they brought us remains, which seemed to us to be those of an emu. Mr Kendall [the English missionary Thomas Kendall (1788–1832)], confirms this belief by asserting the existence of cassowaries analogous to those of Australia in the woods of New Zealand. We do not doubt today that it must be the *Apterix* [*sic*] *australis* of Shaw figured on pll. 1057 and 1058, of the 24th volume of his *Miscellany*.'

Further to the above, Lesson also provided in a footnote a description obviously based on Shaw's 1813: text to pll. 1057–1058 "*Character Genericus*" and "*Character Specificus*" (see Lee & Bruce 2019).

In his *Traité d'Ornithologie* (1830: 12) Lesson expanded his initial description (again based on Shaw) and placed his name as a junior synonym of Shaw's name.

Lesson's association of his name with Shaw's has been long misinterpreted in the literature to mean the names applied to the same species, and indeed to the point that both names were associated with the same South Island locality, e.g. Bonaparte (1856), Giebel (1872), Rothschild (1899), Dubois (1913), Mathews & Iredale (1913).

Lesson (1838: 71) again dealt with the *Apteryx* in his *Compléments de Buffon* vol. 2, revealing he was shown the skin by a Bay of Islands chief, almost certainly the Ngare Raumati leader Tui (or Tuai) (1797?–1824). During the visit of *La Coquille* Tui lived on board the ship, but on 10 April formally welcomed Lesson and other crew members, including Dumont d'Urville, to his fortified village or pā called Kahuwera on the nearby Paroa peninsula. This was where Lesson most likely saw the skin (Lee 2018).

Lesson (1839: 348) referred briefly to his discovery again using the name "*l'aptéryx*" in the second volume of his popular book *Voyage Autour du Monde*. Lesson's last recorded reference to *Dromiceius* was in *L'Écho du Monde Savant*, 26 May 1844, under the heading "Sciences Naturelles - Notice sur l'aptérix". In this essay Lesson reviewed all the published work on the *Apteryx* mainly by British scientists, including that of Richard Owen (1804–1892), as well as noting Owen's announcement the previous year regarding the second New Zealand ratite, the giant moa *Dinornis novaezealandiae.* Lesson praised Shaw, revealing that French scientists for many years had ignored Shaw's discovery and that he himself had only become aware of his work in 1829 while preparing his *Compléments de Buffon*. Lesson recalled his erroneous initial impression that the partial specimen he saw was that of a new emu, noting it was to 'serve as a cloak for a New Zealand chief'.

He reported that in recent years 'well-preserved' kiwi specimens had been received in London and at the "Muséum de Paris" (MNHN), noting two 'magnificent individuals' also obtained at the Bay of Islands in May 1840 by his former shipmate Dumont d'Urville (1790–1842), then in command of *La Coquille*, renamed *L'Astrolabe.* Lesson referred to these MNHN specimens as 'precious ornaments in the galleries.' (Fig. 1 & 2). Lesson concluded, 'I have reproduced all the titles on the various writings on the *Apteryx* which have come to my knowledge. It is because the compilers can forget too easily the writings of their predecessors, appropriating without ceremony, before the public, the ideas produced by their predecessors.'

Figure 1. North Island brown kiwi (*Apteryx mantelli*). The specimen illustrated is one of two specimens collected by Dumont d'Urville of *L'Astrolabe* (previously *La Coquille*) at the Bay of Islands in 1840. 'Apteryx austral. Shaw.' Engraving Giraurd after Le Breton and Werner. Plate 24. Pub. 1843. *Voyage Au Pole Sud et dans l'Océanie. Atlas. Zoologie, Oiseaux*. Biodiversity Heritage Library.

Six years later the British zoologist Abraham Bartlett (1812–1897) presented a report on a kiwi specimen sent to London by the New Zealand colonial official Walter Mantell (1820–1895) who had collected it at Dusky Sound. This had appeared to Bartlett to be different in a number of respects to the specimens he was familiar with in various collections such as those of the British Museum and the Royal College of Surgeons. Bartlett was about to describe it so but remembered that Shaw's *Apteryx australis* specimen was in the private collection of the Earl of Derby, (Edward Smith-Stanley, 13th Earl of Derby, 1775–1851). This specimen, the holotype, Shaw had reported was obtained from New Zealand's "south coast" (Shaw 1813: 216.) Access was obtained and an anatomical examination of the specimen found its key diagnostic features to be the same as Mantell's. Bartlett here suggested Shaw's specimen had also originated from "Dusky Bay" on the advice of "J.E. Gray Esq." (Shaw's specimen was soon after bequeathed to the Liverpool Museum, now World Museum, where it is still held [specimen no. D180]).

Figure 2. One of two Northland brown kiwi specimens, collected by Dumont d'Urville of *L'Astrolabe* (previously *La Coquille*) at the Bay of Islands in 1840. Both mounted specimens were rediscovered at the MNHN, Paris in 2018. One of which is on display in the galleries evidently since reported there by Lesson in 1844. The specimen in the photograph is currently held in the zoothèque. The label (inset) on the base reads "Apteryx australis (Shaw.) L'Astrolabe N. ZÉLANDE." These appear to be the oldest specimens of the North Island brown kiwi in existence. Photos: Patrick Boussès, MNHN.

On this basis Bartlett named *all the other* specimens, which he determined "as far as I was able to ascertain" had been provenanced from the North Island, as *Apteryx mantelli* (Bartlett 1852: 274–276). He did not nominate a type and made no mention of the earlier name Lesson had applied to a North Island specimen.

Then, 83 years later, Gregory Mathews (1876–1949), reviewed Bartlett's name and concluded that as Lesson's name preceded Bartlett's by 24 years, and was based on specimen material seen at the time, the North Island brown kiwi, then considered a subspecies of *A. australis,* "must be called *Apteryx australis novae-zelandiae* (Lesson 1828)" (Mathews 1935: 179). Mathews (1937, 1946) reiterated this recommendation albeit with the spelling "*novaezealandiae*", an incorrect subsequent spelling first used by Gray (1840). Nonetheless, it was the original spelling (see Article 32.2.3 of ICZN 1999) first used by Mathews (1935) in his proposal to replace *mantelli* as the oldest name for the North Island brown kiwi.

Mathews indicated that kiwi populations within the North Island might be separable and thus regarded *mantelli* as representing another potentially distinct population, predicting "It is possible that the bird for the south of the North Island may differ from that of the north so that *mantelli* Bartlett may come into use for the former." Mathews selected "Wellington Province", originally covering the southern half of the North Island, as its type locality (Mathews 1935: 179). However, the second species of kiwi (sub-fossil remains) identified over much of the southern North Island proved to be an extinct population of *A. rowi* (Gill *et al.* 2010). Following his death Mathews' work fell out of favour, particularly after the assessment by Serventy (1950) and his criticism of "Mathewsian names". This may explain why, in the first official *Checklist of New Zealand Birds* (Fleming 1953), the entry for "Apterygidae: Kiwis" ignored Mathews (1935, 1937, 1946), and instead announced: "As there has not been a recent investigation of the morphological and distributional relationships of the kiwis, a modification of the arrangement of Mathews (1931) is presented." The *Checklist* identified one species of brown kiwi with three subspecies, North Island, South Island and Stewart Island and two species of spotted kiwi (little spotted and great spotted). This treatment was followed in the next two checklists (Kinsky 1970; Turbott 1990). However, the fourth and current *Checklist* (Gill *et al.* 2010: 19), taking into account the results of recent advances in genetic research, in particular Holdaway *et al.* (2001) and Tennyson *et al.* (2003), recognises five species and two subspecies of kiwi. These five species include three of brown kiwi, *A. australis* (*A. a. australis, A. a. lawryi*), *A. mantelli* and the newly named *A. rowi*, plus the little spotted kiwi *A. owenii* and great spotted kiwi *A. haastii.* Gill *et al.* (2010) noted Lesson's name "*Dromiceius Novae Zealandiae*" [*sic*], which along with two others was dismissed on the grounds of being "historical names not based on localised specimens or adequate descriptions…unable to be referred to known taxa".

Recent and ongoing mtDNA analyses of kiwi populations are revealing a dramatic and previously unappreciated level of genetic diversity in largely morphologically cryptic populations of kiwi, indicating a taxonomic reality that has yet to be fully reflected in nomenclatural terms (*cf.* Shepherd & Lambert 2008; Craig *et al.* 2010; Shepherd *et al*. 2012; Weir *et al*. 2016; White *et al.* 2018). Craig *et al.* (2010) provided the officially accepted common name 'Northland brown kiwi' for the "genetically distinct" Northland taxon within *A. mantelli.* Moreover, Weir *et al*. (2016: E5581-82) identified 11 extant kiwi taxa, confirming four genetically distinctive allopatric populations, including the Northland taxon, within *A. mantelli* that they argue merit status as "distinct subspecies".

Just prior to the appearance of the *Checklist* by Gill *et al.* (2010), but too late to be included therein, Shepherd *et al.* (2009) selected a neotype for *A. mantelli*, collected at Ohakune in the central North Island which we note is within the habitat range of the "western taxon" of Craig *et al*. (2010) and Heather & Robertson (2015) and also the proposed "Taranaki" subspecies of Weir *et al.* (2016) (and interestingly just within the northern limits of Mathews' proposed type locality).

Shepherd *et al.* (2009) could find no reliably traceable or sufficiently preserved North Island brown kiwi specimens in the United Kingdom dating from Bartlett's time, but as the result of an inquiry related to Lee (2018) and Lee & Bruce (2019) both kiwi specimens collected by d'Urville in 1840 from the Bay of Islands (Dumont d'Urville 1846: 183-184) have been rediscovered in the MNHN in Paris, numbered 15560 and 15562, "Ancien catalogue" (Patrick Boussès *pers. comm.* 04 July 2018). These evidently well-preserved mounted specimens of the Northland taxon appear to be the oldest North Island brown kiwi specimens in existence (Fig 2.)

Lesson's kiwi description was based on specimen material (although evidently uncollected), its "*grisâtre*" ('greyish') feathers compatible with plumage descriptions of North Island brown kiwi (Oliver 1955; Heather & Robertson 2015), with a region-specific locality, the inner Bay of Islands. Furthermore, we note the name has been used as valid since 1899 – see Article 23.9 of the Code (ICZN 1999). We suggest that if the taxonomic status of the Northland brown kiwi taxon is elevated to subspecies rank as proposed by Weir *et al.* (2016) then Lesson's (and Mathews') name *novaezelandiae* could be reconsidered.

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SHORT NOTE

Grey warbler (*Gerygone igata*) aggressive behaviour towards rifleman (*Acanthisitta chloris*) fledglings

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Organisms interact with one another to form complex ecological networks that involve intricate relationships between species. Agonistic behaviour between heterospecifics, in which individuals of one species are aggressive towards another, can elucidate direct and indirect inter-species competition and threats. New Zealand forests, with their unique avian communities, offer an ideal system to study these aggressive interactions.

Several native New Zealand birds, such as the bellbird (korimako, *Anthornis melanura*; Withers 2009) and brown creeper (pīpipi, *Mohoua novaeseelandiae*; Gray 1969), are known to show aggression towards rifleman (tītitipounamu, *Acanthisitta chloris*), the smallest New Zealand bird. Here, we describe the vocal and physical behaviours of rifleman in response to aggression from other New Zealand bird species, in particular the grey warbler (riroriro, *Gerygone igata*; Stidolph 1939), tūī (*Prosthemadera novaeseelandiae*), and North Island robin (toutouwai, *Petroica longipes*). Because aggression from grey warblers was the most commonly observed, we then focus on grey warbler aggression and contrast it with the levels of aggression observed from other species (bellbird, tūī, and North Island robin) towards rifleman. In addition, grey warblers are a similar size to rifleman (rifleman 5–7 g, grey warblers 6 g). Finally, we suggest possible explanations for the aggressive behaviour of grey warbler towards rifleman fledglings.

From September 2018 to February 2019, we monitored a rifleman population throughout their breeding season in Boundary Stream Mainland Island Reserve, New Zealand (39°06′15.8″S, 176°48′06.1″E). In particular, upon fledgling, we recorded the vocalisations of rifleman fledgling groups using Zoom H6 digital recorders (Hauppauge, NY) with Sennheiser K6 microphones (Sennheiser electronic GmbH & Co. KG, USA). Rifleman fledglings stay in natal groups, usually consisting of three to four fledglings, for four to five weeks post-fledging, and are dependent on their parents to supplement their feeding (Sherley 1985). During this time they produce broadband frequency calls that are conspicuous acoustically; this makes them easily detectable and distinguishable from rifleman adult vocalisations. Their dull grey plumage and streaks on the throat and chest can also be used to distinguish rifleman fledglings from adults (Higgins *et al*. 2001; Withers 2013). While monitoring the rifleman population in Boundary Stream Mainland Island, we observed a number of aggressive behaviours towards rifleman from native New Zealand birds.

We observed grey warblers chasing rifleman fledglings on four occasions, from 30 November to 27 December 2018. In all cases, the rifleman fledglings were between two days and 15 days

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post-fledging. In each chasing event, an adult grey warbler silently chased a single fledgling, during which the rifleman fledgling produced distress calls in flight (Fig. 1a). In two cases, this triggered alarm responses from the rifleman parents (Fig. 1b). The length of the chases varied from a few seconds, where the grey warbler briefly pursued a fledgling, to a few minutes, where the chase was persistent and involved longer aerial loops in the tree foliage. On another occasion, two chases in the same fledgling group were recorded eight minutes apart during which the rifleman parents produced agitated calls and alarm trills in response to the grey warbler's presence and chasing of the fledglings. Interestingly, we observed that chases exclusively occurred between the adult grey warblers and rifleman fledglings, and not between adults of both species.

We also observed aggression from adult bellbirds towards rifleman juveniles, a behaviour that has been reported before (Withers 2009). During our observation, a female bellbird seized a rifleman fledgling with its beak while flying. Both of them then dropped to the ground and the fledgling escaped. The rifleman parent of the fledgling group produced alarm calls directed at the attacker until it flew away from the area. Additionally, we observed robins and tūī chasing adult rifleman at our field site. The robin initiated the chase while the individual rifleman was foraging in the tree branches. In the case of the tūī, an adult rifleman pair mobbed a tūī approximately 20 meters from their fledgling group which resulted in the tūī showing aggression towards the adult pair. The tūī chased the adult pair for approximately 10 seconds before leaving the area.

Overall, we found that grey warblers, bellbirds, robins, and tūī showed varying levels of aggression towards rifleman: the bellbird chased and physically attacked rifleman fledglings, the grey warbler only chased the fledglings and not the adults, and the robin and tūī chased only the adult rifleman.

Interspecific aggression between bird species can result in competitive exclusion, niche differentiation, and even local extinction, and may explain species speciation and species distribution (Robinson & Terborgh 1995; Jankowski *et al.* 2010; Freeman *et al.* 2016; Bauer & McDonald 2018). We suggest three non-mutually exclusive explanations why grey warbler chase rifleman fledglings: (1) territoriality to defend resources, (2) competition for food, and (3) interspecific overlapping of acoustic niches.

Rifleman are sedentary birds that do not disperse far from their natal territories (Gill 1980a) and do not defend strong territory boundaries, while grey warblers are territorial and maintain territories with songs year-round (Gill 1982; Cameron 1990). Grey warblers also settle territorial disputes by chasing intruders (Gill 1980b). The resources that territorial birds defend may range from feeding resources, nests, fledgling groups, mates, and an area of forest. Hence, grey warblers may chase rifleman fledglings that trespass into their territories. It is unclear why grey warblers do not chase adult rifleman. Perhaps adults are less vulnerable or are able to return

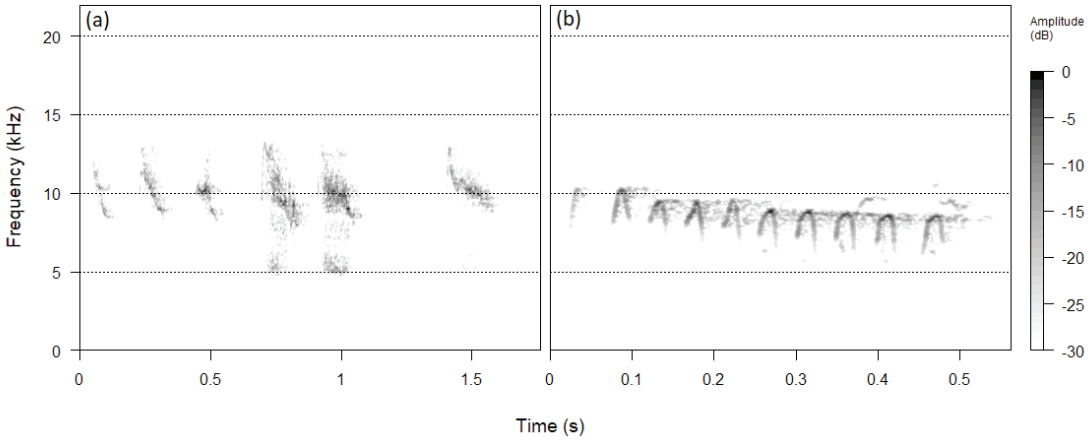

Figure 1. Spectrograms showing the frequency and amplitude of (a) a distress call produced by a juvenile rifleman at two days post-fledging while being chased by an adult grey warbler, and (b) an alarm trill produced by the female parent rifleman in response to the warbler chasing its fledgling. The sound clip was recorded in Boundary Stream Mainland Island on 30 November 2018 (recordist YYL). The spectrograms were made with Seewave for R (Sueur *et al*. 2008). The recording is available on Xeno-Canto (www.xeno-canto.org, XC475016).

aggression as they are of a similar mass.

Secondly, many bird species have overlapping territories but do not show aggression towards one another. However, competition for similar resources may drive aggression. This may be the case with rifleman and grey warblers that forage the majority of their time on silver beech (*Nothofagus menziesii*) and kamahi (*Weinmannia racemosa*) trees (O'Donnell & Dilk 1994). They also share a similar insectivorous diet of mainly spiders, beetles, caterpillars, and moths (Moeed & Fitzgerald 2012). Consequently, resource competition and partitioning may underlie the agonistic interactions between rifleman and grey warblers. As rifleman fledglings may forage for a few weeks on grey warbler territories (Gill 1978; Sherley 1985), this may trigger grey warblers to be aggressive towards rifleman fledglings.

Thirdly, overlapping acoustic niches can trigger aggressive behaviour between individuals of the same species (Hall *et al*. 2006; Naguib & Mennill 2010). However, no studies to date have tested whether interspecific acoustic overlapping generates interspecific aggressive behaviour, although a few studies have shown that species avoid singing during the song of another species (Popp *et al*. 1985; Brumm 2006). On the other hand, acoustic niche partitioning can occur between species of insects and birds. For example, when cicadas sing, bird species tend to either adjust their vocalisations or avoid vocalising during this period (Hart *et al*. 2015). Our recordings show that the contact calls of rifleman fledglings (8–11 kHz; Fig. 2a) overlap with that of the grey warbler fledglings (8–9 kHz; Fig. 2b; Higgins & Peter 2002). We suggest that interspecific acoustic overlapping may generate interspecific aggression in birds. When grey warblers produce their songs during the breeding season (Gill 1980a), rifleman fledgling vocalisations may overlap temporally with grey warbler songs that function as territorial and mate attraction signals. In addition, the loud and conspicuous rifleman fledgling vocalisations (Higgins *et al*. 2001) may interfere with grey warbler parent-fledgling vocal communication.

In summary, we have observed and documented grey warbler adults chasing rifleman fledglings – a previously undescribed observation. We suggest that this aggressive behaviour may be caused by competition for either territory, resources, or acoustic space, and highlight the importance of describing heterospecific behaviours to further understand the ecological relationship between species.

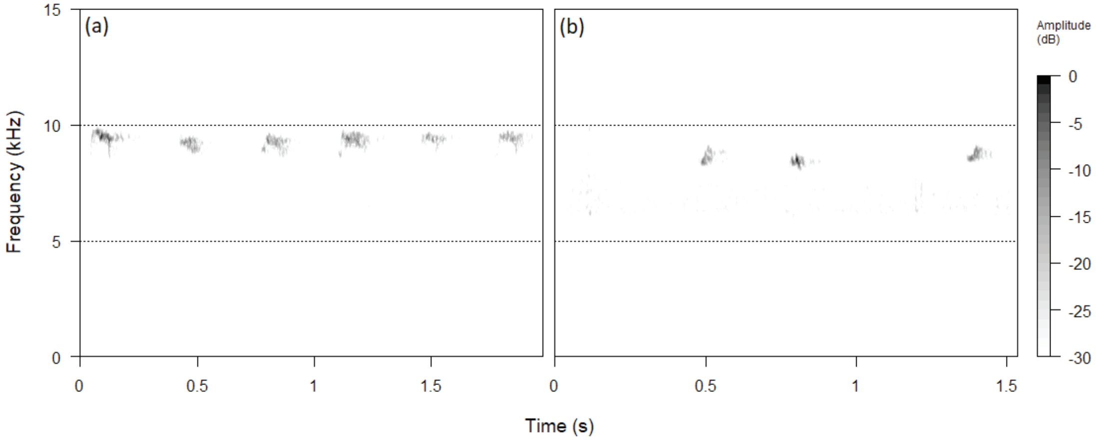

Figure 2. Spectrograms of (a) a rifleman fledgling and (b) a grey warbler fledgling from Boundary Stream Mainland Island. Grey warbler fledgling vocalizations (8–9kHz) overlap with the acoustic niche of rifleman. The sound clips of the rifleman and grey warbler fledglings were recorded in Boundary Stream Mainland Island on 1 December 2018 (recordist YYL) and 5 December 2018 (recordist IGM), respectively. The spectrograms were made with Seewave for R (Sueur *et al*. 2008). These recording are available on Xeno-Canto (rifleman fledgling: XC476225; grey warbler fledgling: XC475017).

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SHORT NOTE

A vagrant Buller’s albatross (*Thalassarche bulleri*) in Uruguayan shelf waters: northernmost record in the Southwest Atlantic

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Buller’s albatross (*Thalassarche bulleri*) is a New Zealand breeding endemic, with colonies distributed on four island groups (Onley & Scofield 2007; ACAP 2009). The breeding population is estimated to be of about 32,000 pairs, about half of which are concentrated on the Chatham Islands and the remaining on the Snares and Solander Islands, and Rosemary Rock in the Three Kings Islands (ACAP 2009; Birdlife International 2018). Juveniles and non-breeding adults migrate across the Pacific Ocean to feed in the Humboldt Current off Chile and Peru, where Buller’s albatross occurs frequently (Stahl & Sagar 2000; Spear *et al*. 2003). Contrastingly, there are only a handful of records of Buller’s albatrosses in the Atlantic Ocean. It is a rare vagrant in South African waters, where there are six records of birds observed around fishing trawlers operating to the south-west of Cape Point (August 1995, November 2003, November 2008) and to the south of Cape Agulhas (October 2005, October 2010, May 2016) (Ertel & Rose 1997; Ryan 2017; Trevor Hardaker *pers. comm.*). In the Southwest Atlantic Ocean, there are just three reports of its presence, all of them from sub-Antarctic latitudes. The first one corresponds to three individuals observed on 28 March 1987 at the southern entrance to the Falkland´s Sound (Curtis 1988). The other two records were located farther south; a single bird was recorded on 5 March 2012 north of Orkney Island (59°39´S, 45°49´W; Orgeira *et al*. 2013), and another single individual was spotted on 15 December 2012 associating with a fishing vessel off the southernmost Atlantic coast of Argentina (55°06´S, 66°06´W; Tamini & Chavez 2014). Here, we provide information on the first occurrence of Buller’s albatross in Uruguayan waters, bringing evidence that vagrant individuals of this species venture northwards into the Southwestern Atlantic.

On 8 October 2015, a Buller’s albatross was observed from the research vessel RV *Aldebarán*, while it was conducting a demersal fisheries survey over the outer continental shelf within the Uruguayan Exclusive Economic Zone (EEZ) (between 50 and 300 m depth). The albatross had a grey head and neck, which contrasted with the white breast, forehead, and crown. A dark smudge was present in front of the eyes, as well as a clearly visible white crescent behind and below the eyes. The bill had black latericorns and vivid yellow maxillary unguis and culmen, which was broadly rounded at the base. The presence of yellow lines along the lower margins of the ramicorn was also obvious. The underwing had a broad, well-defined black band at the leading edge, widest at

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the axilla. All these features, visible on Figures 1 and 2, indicate that the bird was an adult Buller´s albatross (Harper & Kinsky 1974; Onley & Scofield 2007; Howell 2009). The almost white forehead and prominent front of crown (visible on several of the photographs obtained during the sightings) indicate that this individual was a southern Buller's albatross (*T. b. bulleri*).

The individual was initially spotted at 1558 h, 150 km south-east (35°49.32'S, 53°19.46'W) of La Paloma. Water depth was 115 m and SST was 11.8°C. When first observed, the bird was sitting on the surface roughly 50 m ahead of the vessel, which was conducting a trawl. After the initial detection, the individual was tracked as it mingled between several tens of other seabirds. It continued to be associated with the vessel during the remaining tow time, net hauling operation, and then at least for 15 minutes more while the vessel was on transit towards the next sampling station, to be conducted next morning. The bird was last seen at 1645 h. Individuals of at least twelve other seabird species were attending the vessel when the Buller's albatross was observed, including wandering-type albatross (*Diomedea exulans* sensu lato), southern royal albatross (*Diomedea epomophora*), northern royal albatross (*Diomedea sanfordi*), black-browed albatross (*Thalassarche melanophris*), Atlantic yellow-nosed albatross (*Thalassarche chlororhynchos*), shy-type albatross (*Thalassarche cauta/steadi*), white-chinned petrel (*Procellaria aequinoctialis*), spectacled petrel (*Procellaria conspicillata*), cape petrel (*Daption capense*), great shearwater (*Ardenna gravis*), sooty shearwater (*Ardenna grisea*), and Wilson's storm petrel (*Oceanites oceanicus*).

The next day, a Buller's albatross was sighted again early in the morning (0719 h), while the vessel was hauling the trawl net, 16 km east (35°50.59'S, 53°08.51'W) of the previous sighting. Water depth was 145 m and SST was 13.1°C. While this observation was brief (it lasted less than two minutes) it was possible to obtain several photographs, which allowed us to determine that it was most likely the same individual observed the day before, based on some matching markings related to worn plumage, moulting feathers (symmetrically moulting an inner primary) and a small greenish smear in the base of the unguis (Fig. 2). There were at least nine other seabird species associated to the vessel during this second observation of Buller's albatross, including wandering-type albatross, northern royal albatross, black-browed albatross, Atlantic yellow-nosed albatross, northern giant petrel (*Macronectes halli*), white-chinned petrel, cape petrel, great shearwater, and Wilson's storm petrel.

The sightings reported here establish the first record of Buller's albatross for Uruguayan waters and constitute the northernmost records in the Southwest Atlantic Ocean. The closest records of this species in the Atlantic Ocean (Curtis 1988) were situated at roughly 1,900 kilometres to the south. While several hundreds of seabird counts have been done both from longline and trawl vessels operating over the Uruguayan shelf and slope during the last 15 years (Jiménez *et al*. 2011, 2012, *unpubl. data*), this species was never recorded before. Over five hundred seabird counts have been done since the observations reported here, but no further Buller's albatross has been recorded (*unpubl. data)*. These facts highlight the rareness of this species in the region and suggest that only vagrant individuals reach Uruguayan waters.

Figure 1. Buller's Albatross observed in Uruguayan waters on 8 October 2015.

Figure 2. Buller's Albatross (probably the same individual) observed on two consecutive days (8 & 9 October 2015).

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