

Observations of collared petrels (*Pterodroma brevipes*) on Vanua Lava, Vanuatu, and a review of the species' breeding distribution

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Abstract We report a polymorphic population of collared petrels (*Pterodroma brevipes*) apparently breeding on Vanua Lava, northern Vanuatu, in the austral autumn-winter. This is one of only 5 known extant colonies of the species. One of the 2 birds captured by us matched the description of the recently described dark plumaged *Pt. b. magnificens* which had never been reported caught ashore previously. However, the other bird caught was a paler individual indicating that the taxon is variable in plumage colour, like other *Pt. brevipes* populations. We suggest that the 2 other criteria used to define the subspecies *Pt. b. magnificens* (body size and breeding chronology) are also questionable and require further investigation.

Tennyson, A.J.D.; Miskelly, C.M.; Totterman, S.L. 2012. Observations of collared petrels (*Pterodroma brevipes*) on Vanua Lava, Vanuatu, and a review of the species' breeding distribution. *Notornis* 59 (1&2): 39-48

Keywords Collared petrel; *Pterodroma brevipes magnificens*; Vanuatu; conservation; plumage colour

INTRODUCTION

Known breeding distribution

Collared petrels (*Pterodroma brevipes* (Peale, 1848)) are a poorly known species with breeding reported from only a few widespread sites. In Fiji, breeding populations are currently present on Kadavu and Gau, though historical records show that the species previously nested on Ovalau and Viti Levu, most likely having been extirpated from the latter island by mongooses (*Herpestes auropunctatus*) (see Ramsay 1882; Bourne 1981; Watling 1986; BirdLife International 2011a). Breeding of collared petrels is also assumed to have occurred historically on

Vanua Levu, although there seems to be no firm evidence of this (Watling 1986, 2001). Breeding is suspected on Taveuni, Koro, Moala, Totoya and Matuku (e.g., Watling 2001; BirdLife International 2011b; D. Watling, *pers. comm.*). Additionally, an historical specimen was collected ashore on Vanua Balavu (Watling 1986; National Museums Liverpool T.16061), which indicates that the species may have bred there also.

Collared petrels have been found ashore on Rarotonga on a few occasions, including a fledgling on 26 Jul 1984 (Museum of New Zealand Te Papa Tongarewa (NMNZ) OR.023110) but have not been reported there since 1995 and they may be locally extinct (BirdLife International 2011a; E. Saul, *pers. comm.*; G. Taylor, *pers. comm.*). Specimen NMNZ

Received 15 Jul 2011; accepted 20 Mar 2012

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OR.023110 was previously incorrectly labelled as being found in Sep 1984 (Watling 1986; Bretagnolle & Shirihai 2010). The remains of 2 birds, considered to be collared petrels, killed by predators were collected on Raivavae, Austral Islands, on 29 Jul 1992 (NMNZ OR.025376 & OR.025377) and *Pterodroma* petrels, probably *Pt. brevipes*, were reported there in 1989 and on several subsequent occasions (Seitre & Seitre 1991; Raust 2007; J. Champeau, *pers. comm.*), indicating another potential breeding site. However there is on-going debate about whether the Raivavae "colony" actually may be of Gould's petrel (*Pterodroma leucoptera* ssp. (Gould, 1844)) (see BirdLife International 2000, 2011a; Onley & Scofield 2007). Records from Moorea and Tahiti suggest a local breeding colony: at least 5 individual small *Pterodroma* petrels, most if not all *Pt. brevipes*, have been reported ashore mainly attracted to lights, including 1 probable fledgling on Moorea on 28 Jul 2000 and 4 birds on Tahiti – an adult on 21 May 2004, 1 on 6 Feb 2009, 1 in flight on 31 May 2010, and a fledgling on 16 Jul 2010 (Anon 2000, 2001, 2004, 2010a & b; Champeau 2010; Gangloff 2010; BirdLife International 2011a; J. Champeau, *pers. comm.*). There are several other possible but unconfirmed breeding locations spanning most of the width of the Pacific Ocean, including the Duke of York Is (Bismarck Archipelago) (Finsch 1879; Bourne 1974), Makira I (Solomons) (Bourne 1974, 1983; Fisher 1981; Onley & Scofield 2007; BirdLife International 2011a; National Museums Liverpool T.16064), Upolu I (Independent Samoa) (Bourne 1967, 2008; Watling 1986) and Mangareva I (Gambier Is) (Thibault & Bretagnolle 1999). Recent searches for *Cookilaria* petrels (*sensu* Murphy 1929) ashore on Makira (BirdLife International 2011a) and Mangareva (Thibault & Bretagnolle 1999) Is have been unsuccessful. Records from Ta'u I (American Samoa) (Amerson *et al.* 1982) probably refer to herald petrels (*Pterodroma heraldica* (Salvin, 1888)) (Pyle *et al.* 1990; Watling 2001; BirdLife International 2011a), although recent occurrences of stranded collared petrels on Tutuila (O'Connor & Rauzon 2004) might indicate nesting at either American or Independent Samoa.

In Vanuatu, breeding collared petrels have been reported on the southern islands of Tanna and Aneityum (MacGillivray 1860; Bregulla 1992; Bretagnolle & Shirihai 2010). Although Brooke (2004) claimed that the species breeds on "Eramanga" [= Erromango] I, he based his statement on MacGillivray's (1860) supposition, based on the fact that he had "seen it on various occasions off the coast" of Erromango. However, the sole specimen preserved from Erromango (American Museum of Natural History (AMNH) 336476) was collected from a "3' 6" burrow on volcanic peak" on 19 May 1936 by Lindsay Macmillan (P. Sweet, *pers. comm.*),

so was clearly a breeding bird. Furthermore the unpublished notes of Macmillan (1935-37, New Hebrides notes and letters, Whitney South Seas Expedition Volume FF, Department of Ornithology Archives, AMNH) contain the following statement about the species on Erromango: "Nests in the loose volcanic soil of the southern mts. and also in the northern mts. but not to a great extent. A tremendous colony nests in the peaks of Traitor's Head. Many can be heard calling, passing overhead about 8 P.M. and the hills are simply riddled with burrows". SLT confirmed the presence of collared petrels on the summit of Mount Urantop, Traitor's Head, Erromango, on 2 Jun 2011. Evidently the Tanna population still survives as chicks were being harvested in 2008 and 2011 (SLT, *pers. obs.*). The Aneityum records are all from the 19th century (MacGillivray 1860; Bregulla 1992), thus the current status of the species at this location should be considered uncertain. Although the species has been collected on Efate in Vanuatu (Bregulla 1992; Bretagnolle & Shirihai 2010), the single specimen (AMNH 211696) had "small sexual organs" and was "blown ashore starved" on 4 Jun 1926 (Murphy 1929; P. Sweet, *pers. comm.*), so this individual should not be taken as evidence of breeding on that island.

In summary, although there are several possible breeding locations, of the 8 definite breeding sites reported, 2 may no longer be in use (Viti Levu, Rarotonga) and 2 rely solely on 19th century records (Ovalau, Aneityum), leaving only 4 breeding populations known to be extant (Kadavu, Gau, Erromango and Tanna).

Collared petrel taxonomy

Great uncertainty surrounds the taxonomy of collared petrels. Harrison (1983: 248) considered that collared petrels "with characters intermediate between *leucoptera* and *brevipes* or forming undescribed races occur on the Solomons, New Caledonia and New Hebrides [= Vanuatu]". The unique, large Solomon Is specimen certainly requires further examination but it appears to match Gould's petrel in both size (see Bourne 1983) and plumage (AJDT & CMM, *pers. obs. of photos*). The status of the New Caledonian breeding population of *Cookilaria* petrels was clarified when it was described as *Pt. leucoptera caledonica* by Imber & Jenkins (1981) - see Palma & Tennyson (2005).

Bretagnolle & Shirihai (2010) described a new subspecies of collared petrel (*Pterodroma brevipes magnificens*) from northern Vanuatu, based on 6 museum specimens collected at sea. Although they erred by noting 3 separate individuals as the holotype of this subspecies (on pages 288 and 300), we consider that AMNH 216919 is the only holotype designated properly and that the 5 specimens

noted as paratypes on pages 288–289, including the 2 incorrectly reported as "holotypes" on page 300, should be considered the valid paratypes of the taxon. *Pterodroma b. magnificens* was reported to differ from nominate *Pt. brevipes* by (1) being darker and monomorphic, (2) having smaller average dimensions, and (3) apparently being an austral summer breeder. Pale and dark morph collared petrels were reported from Vanuatu as long ago as 1860 (MacGillivray 1860; Salvin 1891; Godman 1908–1910: 209–211, plate 57) but Watling (1986) considered collared petrels from Vanuatu to be "predominantly melanistic" (*i.e.*, largely dark plumaged). The southern Vanuatu polymorphic populations had previously been considered a distinct species – *Procellaria torquata* MacGillivray, 1860 – but this taxon was subsequently regarded as a junior synonym of *Pterodroma brevipes* (*e.g.*, Godman 1908–1910: 209; Murphy 1929). More recently, collared petrels in Vanuatu have been considered either a subspecies of *Pt. leucoptera* (*e.g.*, Watling 1986; Marchant & Higgins 1990; Bregulla 1992) or part of a monotypic species *Pt. brevipes* (*e.g.*, Imber & Jenkins 1981; Watling 2001; Brooke 2004), with an acknowledgement that there is variation in the ratios of polymorphic plumages between nesting sites.

Imber (1985) considered that there may be 2 subspecies of collared petrel but did not elaborate on the distribution of these possible forms. In 2007, Bretagnolle suggested that an undescribed taxon related to *Pt. leucoptera* may occur at Vanuatu (Bretagnolle & Shirihai 2010; Bretagnolle *in* BirdLife International 2011a). Dark morph collared petrels were observed regularly at sea in northern Vanuatu waters in 2006, 2007 and 2009, and gathering at dusk off Vanua Lava and Gaua in the Banks Is (Bretagnolle & Shirihai 2010). A local villager told SLT of the presence of both large (= ?Vanuatu petrel *Pterodroma occulta* Imber & Tennyson, 2001 and small (= ?collared petrel) petrels on Vanua Lava in Feb 2009 (Augustin, *pers. comm.*). Vincent Bretagnolle heard calls that were presumed to be *Pt. brevipes* on the ground and in flight on Mt Suretamatai, Vanua Lava (for location details see Totterman 2009), on the night of 26–27 Dec 2009 but did not see any (Bretagnolle & Shirihai 2010; V. Bretagnolle, *pers. comm.*). As a result of Bretagnolle & Shirihai's (2010) observations, they concluded that *Pt. b. magnificens* presumably breeds on Vanua Lava.

Gangloff (2010) carried out a genetic study on the relationships of *Pt. brevipes* and concluded that "this species is likely to be made of several differentiated taxa" and that the "haplotype network suggests that, although closely related, *brevipes* from North ...and South ...Vanuatu might be slightly differentiated genetically". However, his results indicate that the 6 museum specimens collected at sea in northern

Vanuatu actually fall within the range of genetic variation shown by birds from southern Vanuatu and Fiji.

During our visit to Mt Suretamatai in Mar 2011, we encountered several collared petrels. Here we report new information on the plumage, size and breeding season of the species which supports evidence for a nesting colony but highlights uncertainty about the taxonomic status of *Pt. b. magnificens*.

METHODS

While researching the Vanuatu petrel on Mt Suretamatai, we made several novel observations on collared petrels. We camped below the solfatara (Qwelrakrak, altitude 582 m) at the base of the eastern summit (Qonsauru, altitude 794 m) of Mt Suretamatai where we had close access to the only known colony of the Vanuatu petrel.

At night on 5 and 6 Mar 2011, we studied the birds at Qwelrakrak and on 7–9 Mar we also worked on Qonsauru. AJDT and CMM left Vanua Lava on 11 Mar. SLT remained until 28 Mar to explore more of Mt Suretamatai and camped over night on Qonsauru on 15, 17, 23 and 25 Mar; however his primary focus during this time was Vanuatu petrels.

Our observations on collared petrels included listening for calls, recording them and searching for calling birds on the ground. To find, attract and catch birds we also spotlighted with headlamps and torches to illuminate the sky and gave "war-whoops" (Tennyson & Taylor 1990). On 8–9 Mar we erected 20 m of mist nets on Qonsauru to catch birds in flight after dark. Birds caught were individually marked with metal leg bands, blood samples were taken for genetic analyses and parasitic lice were collected. Birds were later sexed using molecular techniques.

SLT also conducted rat index trapping surveys (see Cunningham & Moors 1996) on 15, 17 and 23 Mar. Trapping around Qonsauru (760–800 m elevation) used 50 steel traps baited with roasted coconut, coated with vegetable oil, spaced at ~25 m, with 2 traps per station, on each of 3 nights (*i.e.*, 150 uncorrected trap nights in total).

RESULTS

On 5 Mar at Qwelrakrak we heard a wide range of *Pterodroma* calls but assumed that most, if not all, were given by Vanuatu petrels. By 6 Mar we recognised distinctive calls that we tentatively concluded were given by collared petrels. About 4 aerial "ki-ki-ki..." calls were more rapid and higher pitched than the calls of Vanuatu petrels (we equate these calls with the "ti-ti-ti" calls described for collared petrels by Watling 1986). One of these calls

Table 1. Details of the 2 live collared petrels caught on Vanua Lava, compared with measurements from the type series of *Pt. brevipes magnificens* (Bretagnolle & Shirihai 2010). Measurement techniques follow Marchant & Higgins (1990: 30, 37) except: bill-depth at gonys = height of bill at angle of gonys (Baldwin *et al.* 1931: 20); and wingspan (Powlesland & Imber 1988). Plumage score was based on Watling (1986) and Bretagnolle & Shirihai (2010); unfortunately their plumage score systems differ in that the 8 Mar bird fits a “smoky” morph of Watling but a “grey peppering” morph of Bretagnolle & Shirihai.

	7 March	8 March	<i>Pt. brevipes magnificens</i>
Band number	D-201601	D-201602	
Bill-length (mm)	22.9	23.1	21.5-24.6
Bill-width (mm)	9.5	8.8	9.5-10.4
Bill-depth (mm)	9.6	9.7	
Bill-depth at gonys (mm)	7.8	7.8	7.1-8.3
Total head-length (mm)	57.3	58.6	
Wing-length (mm)	215	217	206-222
Wingspan (cm)	67	70	
Tail-length (mm)	96	96	89-102
Tarsus (mm)	27.4	29.1	25.3-27.8
Mid-toe (mm)	30.8	33.8	
Weight (g)	123	141	
Plumage score	Dark grey	Smoky or grey peppering	
Moult	All plumage fresh	All plumage fresh	
Iris colour	Brown	Brown	
Leg colour	Grey-blue	Pale blue with pink tinge	
Foot colour	Mostly black but inner toe grey-blue with black joints, middle toe half grey-blue & inner third of webbing pink	Mostly black but inner toe blue with black joints, middle toe one quarter blue & inner third of webbing pink	
Brood patch	Scattered down	Covered in grey down	
Cloaca size	Small	Moderate	
Sex	Female	Female	

was preceded by a deeper “borr” call (which we equate with the “thick, low purring” call described by Watling 1986). These calls were reminiscent of those given by *Cookilaria* petrels familiar to AJDT and CMM.

On 7 Mar we spent from dusk (c.1900 hours) to 2300 hours on Qonsauru. A few Vanuatu petrels were heard in flight from 1930–2030 hours and after that the number of Vanuatu petrel calls decreased but aerial “ki-ki-ki...” and “borr ki-ki-ki...” calls were heard commonly. Other rarer aerial calls, assumed to be made by collared petrels, were a higher pitched version of the “borr” call and various squeaks (we equate these calls with the “guorr” and complex “ti”, “qwek” and “cher-cher” calls described by Watling 1986). At this stage a bird flew into us but did not land and flew away again. Our brief observation showed this to be a petite, agile, dark bellied petrel which we assumed to be *Pt. b. magnificens*. We then

had another 5 observations of similar birds, in the beams of our lights, but 2 of these appeared to have paler underparts. We were now confident that our sightings were of collared petrels - in fact, this was the most common species seen in our lights and the most commonly heard species calling in flight after 2030 hours. Using Watling’s (1986) and Bretagnolle & Shirihai’s (2010) plumage score system, our dark birds included “extreme dark grey” and “dark grey”, while our “paler” birds encompassed their 3 paler morphs. Although the birds that we saw in flight were generally only 10-20 m away, the brief views did not allow us to score them more precisely. We also concluded that the “borr” calls intermittently coming from the ground around us in dense wet vegetation (and similar to the aerial calls) were made by collared petrels as the calls did not match those of Vanuatu petrels. At 2200 hours we caught a collared petrel climbing in the vegetation and giving

Fig. 1. Collared petrel, dark grey morph, caught 7 Mar 2001, Vanua Lava, photo A.J.D. Tennyson.



Fig. 2. Collared petrel, paler morph, caught 8 Mar 2001, Vanua Lava, photo A.J.D. Tennyson.



a “borr” call, which matched the description of *Pt. b. magnificens* (see Table 1 and Fig. 1); we released this bird nearby on the ground. Returning down the ridge to Qwelrakrak, from 2300–2330 hours, we continued “war-whooping” to detect Vanuatu and collared petrels. Collared petrel “borr” calls were heard from 22 different locations on the ground for the first 100 m (vertically) below the summit of Qonsauru in dense vegetation in response to “war-whoops” but we heard no such calls lower down the track. These calls were within about 5 m either side of the cliff edge track and appeared stationary, although it is possible that birds hovering low in flight also responded. The brevity of calls also made the positions of the birds difficult to locate.

Only a few calls from collared petrels certainly in flight were heard during this survey. Vanuatu petrels on the ground responded more consistently to the “war-whoops”; about 9 were heard in the same area. The highly intermittent response of collared petrels giving “borr” calls in the vegetation around us while we were at the summit for 4 hours suggested that only a small proportion of birds on the ground called as we descended.

On 8 Mar we returned to Qonsauru at dusk and the 1st petrel calls heard at 1940 hours were from Vanuatu petrels. At 1945 hours the same collared petrel individual caught the previous night was recaptured emerging from ferns. Only a few Vanuatu petrel calls were then heard until

2040 hours when a collared petrel landed just beyond the end of the mist nets and was captured. This individual had notably paler underparts than the first bird captured (see Table 1 and Fig. 2). We neither saw nor heard any collared petrels (apart from the one captured) in flight from the summit this night. We descended to camp from 2300–2330 hours “war-whooping” as per the previous night but heard only 2 “borr” ground calls and about 6 “ki-ki-ki...” or “borr ki-ki-ki...” flight calls from the highest 150 m of track.

On 9 Mar we were on Q̄onsauru from 1915–2400 hours. The 1st aerial Vanuatu petrel calls were heard as we reached the summit and the 1st aerial collared petrel calls were heard at 1955 hours. We had 7 sightings of collared petrels (both dark and paler morph) and ~10 of Vanuatu petrels in flight. However, we neither heard nor saw birds on the ground around us while at the summit nor caught any in the nets. Surveying the highest 150 m of the ridge down to Qwelrakrak, from 2400–0100 hours, we heard 7 collared petrel “borr” calls from different locations on the ground and at least 10 flight calls. We tried to locate each bird calling on the ground but in all cases the birds either stopped calling before we reached them or we established that the birds were either on or over the lip of the ~200 m high cliff above the solfataras. Overall there was much less nocturnal petrel activity on both 8 and 9 Mar than on 7 Mar. Strong northerly winds and occasional heavy rain on the latter 2 nights reduced the effectiveness of our mist netting efforts. We also lacked powerful lights to attract petrels.

Collared petrels were heard from Q̄onsauru giving flight calls on 15, 17, 23 and 25 Mar. On each night the earliest calls were given from 1950–1955 hours. They were also heard 500 m to the northwest of Q̄onsauru but not further afield. On 25 Mar SLT repeated the “war-whooping” survey along the ridge below Q̄onsauru from 2125–2200 hours, hearing 22 collared petrels flight calls but none on the ground. At the same time he heard nine Vanuatu petrel ground calls.

Two species of feather lice of the genus *Halipeurus* were collected from the 2 collared petrels handled by us: (1) a male and 3 females of *Halipeurus pricei* Palma, 2011 - the same species that parasitises collared petrels from Fiji, Rarotonga and Raivavae (Watling 1986; Palma 2011); and (2) a female of *Halipeurus pelagicus* (Denny, 1842) found on bird D-201601. *Halipeurus pelagicus* has not been reported from collared petrels before and its regular natural hosts are 14 species of storm petrels in the genera *Oceanodroma*, *Oceanites*, *Fregetta*, *Hydrobates* and *Halocryptena* (see Price *et al.* 2003: 188). We did not see any storm petrels but heard a single, dual syllable, aerial call (“tear-tear”) of a bird that we thought may be a storm petrel below Q̄onsauru on the night of 7 Mar.

Rat trapping at Q̄onsauru yielded 12.3 captures per 100 corrected trap nights: 16 Pacific rats *Rattus exulans* (confirmed by DNA) and 1 ship rat *R. rattus*. No collared petrel carcasses were found.

DISCUSSION

Colour of Vanua Lava collared petrels

Bretagnolle & Shirihai (2010) diagnosed *Pt. b. magnificens* as “being monomorphic and solely occurring in a dark form” and concluded that its breeding site was Vanua Lava. Our findings indicate that the Vanua Lava population is polymorphic and so in this respect is similar to the other better documented populations of collared petrel. We captured 1 dark morph bird (D-201601) and 1 paler morph bird (D-201602) (both females) and had several further sightings of dark and paler morph birds in flight. The fleeting nature of these sightings did not allow us to categorise these birds on the basis of the different detailed plumage types and it was impossible to know how many individuals the birds in flight represented as we may have double-counted some, so we are uncertain of the ratio of different colour forms occurring on Vanua Lava.

At Fijian collared petrel colonies, the proportion of “dark birds” [= “dark grey” morph] is “at the most 17%” (Bretagnolle & Shirihai 2010, based on Watling 1986); our limited observations support the conclusion that the Vanua Lava population contains a higher proportion of dark birds than those populations. Nonetheless, our records contradict Bretagnolle & Shirihai (2010) in revealing that collared petrels on Vanua Lava are not exclusively dark morphs.

Size of Vanua Lava collared petrels

All but 2 of the measurements of the collared petrels that we caught on Vanua Lava fell within the published range of measurements for *Pt. b. magnificens* (Table 1). The bill-width of D-201602 was 0.7 mm smaller than the published range, however this is a difficult measurement to take consistently and Bretagnolle & Shirihai (2010) did not describe how they measured bill-width, so the measurements may not be comparable. The tarsus length of D-201602 was slightly larger (by 1.3 mm) than the published range.

The 2nd bird caught (D-201602) was an important find for 2 reasons: (1) it showed that paler morph birds occur on Vanua Lava, and (2) that a pale bird can be of similar size to *Pt. b. magnificens*. Bretagnolle & Shirihai (2010) excluded a slightly larger “pale-bellied” bird (AMNH 216923; collected at the same locality and same date as the type series of *Pt. b. magnificens*) from their description of *Pt. b. magnificens* because they considered all members of this taxon to be dark morphs. AMNH 216923 also

differed in having small gonads. However, our finding of paler morph birds ashore on Vanua Lava shows that plumage colouration was not a valid reason for excluding it. Additionally, genetic results indicate that AMNH 216923 is closely allied with the *Pt. b. magnificens* type series (Gangloff 2010). Inclusion of AMNH 216923 with the type series in a size comparison would reduce mean differences and increase overlap between northern Vanuatu collared petrels and other populations.

Breeding season of collared petrels on Vanua Lava

The 3rd reason for Bretagnolle & Shirihai (2010) considering *Pt. b. magnificens* to be distinct from other populations of collared petrel was their conclusion that it was an “austral summer” breeder, however, their logic in reaching this conclusion seems flawed. The evidence that they presented was that: (a) “Birds collected in late January had enlarged gonads”; (b) Totterman (2009) visited the area in Mar 2009 but did not detect any collared petrels; (c) “Many ...if not most” birds seen at sea in late Dec 2009 were interpreted as being recent fledglings. Additionally Bregulla (1992: 85) reported that the species had been “reported in the Banks Islands from August to March”, however his sources were not referenced.

Our observations help improve understanding of the breeding season and this will be refined further when active nests are found. Although it has been suggested that collared petrels may be sedentary in the non-breeding season (e.g., Bourne 1983; Watling 2001; Brooke 2004), during this time the population in Fiji appears not to come ashore and is far rarer in Fijian waters. Watling and his team have made monthly observations on collared petrels on Gau and found the species to be active over the island from Jan to Jul, with peak numbers in Feb-Mar; there are only rare records of the species in Fijian waters between Aug and Dec (D. Watling, *pers. comm.*). Collared petrels were active, flying and calling, every night in Mar that we made observations on Qonsauru but the number of calls heard between nights varied considerably. Vocal activity at *Pterodroma* colonies is mainly courtship behaviour by non-breeders (e.g., Simons 1985; Tennyson & Taylor 1990; Warham 1996: 272) and nightly colony attendance of non-breeding *Pterodroma* petrels is highly variable (e.g., Imber *et al.* 1994, 2005), so the amount of vocal activity can vary greatly from night to night. Therefore the level of vocal activity recorded during our visit is consistent with expected activity during the breeding season.

One of the collared petrels caught by us had only scattered down on its brood patch. *Pterodroma* petrels (including some non-breeders) generally have bare or partly bare brood patches only shortly before incubation through to early chick rearing (Warham 1990: 304-305; Tennyson 1991; AJDT &

CMM, *pers. obs.*). Scattered down therefore indicates that incubation of collared petrels on Vanua Lava is likely to be during or close to Mar.

Our observations suggest an egg and chick period for collared petrels on Vanua Lava of approximately Mar to Aug, which is similar to the breeding timetable of other collared petrel colonies (see Watling 1986; Bretagnolle & Shirihai 2010). Pre-breeders collected in Vanuatu waters in Jan might therefore be expected to have “enlarged gonads”. The 14 Feb record of a “young bird, not many days old, and covered with black down” on Aneityum (MacGillivray 1860) is unusual as no other collared petrel chicks have been reported that early in the year; it may refer to a different species, especially as downy chicks of *Cookilaria* petrels are normally grey above and paler below (Marchant & Higgins 1990; AJDT & CMM, *pers. obs.*), including those of collared petrels (Murphy 1929; D. Watling, *pers. comm.*). Similarly, a “juvenile” collected from the upper Rewa River, Viti Levu, in Mar 1878 by W.J. Abbott (Bourne 1981; Australian Museum A.1498) is fully feathered - it may be immature but is unlikely to be a fledgling (AJDT, *pers. obs. of photos*). There is little evidence to back Harrison’s (1989) suggestion that collared petrels breed throughout the year, and the record of fledglings in Feb appears to be an error. We surmise that the birds seen at sea off the Banks Islands in late Dec and thought to be recent fledglings (Bretagnolle & Shirihai 2010) were more likely to be freshly moulted pre-breeding adults and that Bretagnolle detected some birds of similar status calling over the colony at the same time. Furthermore, recent fledglings in late Dec would indicate that breeding was completed by the beginning of summer which conflicts with Bretagnolle & Shirihai’s own theory that *Pt. b. magnificens* is an “austral summer” breeder.

Although Totterman (2009) was on Vanua Lava in early Mar 2009, he was only present near Qwelrakrak on 2 nights in Feb (not “March”) that year (and 1 night in Feb 2007). Totterman (2009) did not note collared petrels ashore in Feb because he was unfamiliar with the aerial calls of both Vanuatu and collared petrels and spent only a few hours making nocturnal observations. Therefore he did not observe that 2 species were present. Bretagnolle & Shirihai (2010) misinterpreted this absence of evidence as possibly being evidence for absence of collared petrels.

Population size and conservation threats

Our observations indicate that a substantial population of collared petrels (at least dozens and probably more) nest around Qonsauru on Mt Suretamatai. There are several high vegetated peaks on Vanua Lava, so the species could be in much larger numbers on this island. Bretagnolle &

Shirihai (2010) speculated that collared petrels may also nest on nearby Gaua I and it seems likely that the species is more widespread in Vanuatu than previously realised. However only 3 confirmed colonies survive in Vanuatu (Erromango, Tanna and Vanua Lava). With the 2 Fijian colonies, there are therefore only 5 known extant breeding colonies worldwide.

Cats (*Felis catus*), pigs (*Sus scrofa*) and rats are present on Vanua Lava (authors, *pers. obs.*) and while these predators may well be a threat to the collared petrel population, we found no direct evidence of predation on this species. However, for Vanuatu petrels at low altitudes we did find cat-killed remains and evidence of nest predation by rats. Rats may be the biggest threat to collared petrels, as trapping showed that substantial numbers of rats are on Mt Suretamatai. The apparent cliff edge nest sites of collared petrels among dense, often wet, vegetation probably provide some protection against introduced predators on Vanua Lava. Villagers reported feral dogs (*Canis familiaris*) in the bush but we did not encounter any.

Villagers on Tanna harvest collared petrel chicks annually in Jun-Jul, with the aid of dogs (SLT, *pers. obs.*). While Vanua Lava villagers historically harvested Vanuatu petrels until the 1940s (Totterman 2009), apparently they had not taken collared petrels, although an elderly villager knew that the species existed and called it “wiguir” (Augustin, *pers. comm.*). There is the potential that petrel harvesting on Vanua Lava could be encouraged by interest in petrels generated by researchers such as ourselves and the creation of tracks could allow predators easier access to the petrels. It is possible that the high-altitude colony of collared petrels on Vanua Lava is just a remnant of a once much larger population but the pre-human breeding distribution of the species on Vanua Lava, and the rest of Vanuatu, is unknown.

Until surveys of the other potential breeding sites are made, it is uncertain what risk an eruption of Mt Suretamatai poses to the Vanua Lava population (Mt Suretamatai last erupted in 1965; www.volcanolive.com/vanualava). Nevertheless, only breeding birds and young in burrows might be killed by such an event. Other natural threats include predation by peregrine falcons (*Falco peregrinus*) and possibly swamp harriers (*Circus approximans*), which are both present on Mt Suretamatai (Totterman 2009; authors, *pers. obs.*). Collared petrels form a large percentage of the prey items of peregrine falcons in Fiji (*e.g.*, Clunie 1976; Worthly 2000).

The feather louse *H. pelagicus* collected from a collared petrel and a single aerial call suggest that storm petrels (unknown species) may also nest on Mt Suretamatai. Transfer of lice between individuals of different species can only occur when birds are

in close physical contact and, in the case of petrels, most likely at the nest (R. Palma, *pers. comm.*). The only storm petrel species reported to nest in Vanuatu is the Polynesian storm petrel (*Nesofregatta fuliginosa* Gmelin, 1789) (Bregulla 1992: 94) but a different species of *Halipeurus* louse parasitises this bird (Price *et al.* 2003: 188, 369), so the *H. pelagicus* specimen probably originated from another species of storm petrel.

With at least 2 little-studied procellariiform species nesting on Vanua Lava, this island is clearly of considerable scientific and conservation significance.

CONCLUSION

Vanua Lava is 1 of the few known locations with an extant colony of the poorly studied collared petrel. The population here is polymorphic, with both dark and paler morph birds, but there may be a higher proportion of dark birds than at other colonies. Further information on variation in plumage, vocalisations, morphometrics, genetics, at-sea distribution and breeding chronologies from all collared petrel populations is needed to determine whether the differences reported by Bretagnolle & Shirihai (2010) are best defined by taxonomic division or represent clinal variation across the range of the species.

ACKNOWLEDGMENTS

Our Vanuatu research was supported by the community of Lalngetak and the Vanuatu Department of Environmental Protection and Conservation (DEPC). We particularly acknowledge our fellow team members Manman and Ala of Lalngetak Village and Anaclet Philip of the DEPC, whose bush skills and effort enabled us to undertake the fieldwork reported here. Martin Lewis and Jean-Claude Stahl (Te Papa) helped locate many relevant publications. Ricardo Palma (Te Papa) identified feather lice and supplied additional information on them. Lisa Matisoo-Smith (Otago University) confirmed rat identifications using DNA. Ed Saul, Gerald McCormack and Graeme Taylor supplied information about the status of collared petrels on Rarotonga, Julie Champeau (Société d’Ornithologie de Polynésie MANU) provided information about the species in French Polynesia, and Dick Watling (NatureFiji-MareketiViti) provided much information on collared petrels in Fiji. Paul Sweet and Mary LeCroy provided information about the AMNH specimens and Macmillan’s unpublished writings. Michelle Houston (Massey University) identified the sex of the petrels based on blood samples. Jaynia Sladek provided photos of the Australian Museum “juvenile”. Tony Parker provided images of the Vanua Balavu and Makira Island birds held in the National Museums Liverpool. Raymond Coory (Te Papa) assisted with preparation of the images. We thank Graeme Taylor (New Zealand Department of Conservation) for helpful discussions about petrels, and the reviewers of this manuscript: Ricardo Palma, Matt Rayner, Dick Watling and Paul Scofield.

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