A PETREL BREEDING DIVERSITY HOTSPOT: RAIVAVAE ISLAND (AUSTRAL ISLANDS, FRENCH POLYNESIA), WITH A NEED FOR CONSERVATION ACTION

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ABSTRACT

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Raivavae is a small island in the Austral Islands of French Polynesia that is surrounded by a lagoon with 28 islets. Its marine avifauna is one of the least known and least studied in French Polynesia. Overall, seabird surveys in the various Austral Islands have been extremely sparse. This study addresses this need, using both historical and recent findings. The results show high species richness, with 10 breeding procellarid species, though none are numerous. We also update the knowledge on breeding petrels from other Austral Islands (except Rapa) and discuss the consequences of these findings in terms of their conservation on an island with cats *Felis* sp. and rats *Rattus* sp.

Key words: invasive predators, distribution, Pacific, Polynesia, population size, *Pterodroma*

INTRODUCTION

In terms of seabirds, Raivavae is one of the least known and least studied islands in French Polynesia (Thibault & Cibois, 2017), especially compared to the island of Rapa and the Gambier Islands, its more well-known neighbours (540 km southeast and 1300 km east from Raivavae, respectively). Rapa has been extensively studied due to the presence of several endemic storm petrels and shearwaters (Flood et al., 2021; Shirihai et al., 2017; Withers et al., 2025). Apart from Rapa, seabird surveys in the Austral Islands (which include Rurutu, Tubuai, and Rimatara in addition to Raivavae) have been scarce (Raust, 2015; Thibault, 2003a). This study seeks to fill this gap, using both historical and recent findings. The study also updates the knowledge on breeding petrels from the other Austral Islands (except for Rapa, which was the subject of a study by Flood et al. (2021)) and discusses the conservation consequences of these findings.

METHODS

Study site

Located about 630 km south-southeast from Tahiti, Raivavae is a small island in the Austral Islands (23°52′S, 147°40′W; Fig. 1). The main island has a total surface area of 17.9 km^2, measuring approximately 8.5 km long by 3.4 km wide, and it is surrounded by a lagoon in which there is a volcanic islet (Hotuatua) and 27 coral islets (Fig. 1). Raivavae is a mountainous volcanic island, with Mount (Mt.) Hiro (438 m above sea level (asl)) as its highest point. It is inhabited, with a population of approximately 1,000 people spread out in four villages. An airport was built on the island in 2002.

Library/museum and field work

To investigate the petrel population of Raivavae, we reviewed all published information over the last century, including grey literature, unpublished reports, and, in some cases, travel journals (Table 1). Published literature on the subject is scarce (Meyer & Claridge, 2014; Raust, 2015), but the data collected over the years comes from visits to the island in all months except for May, June, and October (Table 1).

Measurements were also taken on the few specimens present in museums by VB (i.e., the American Museum of Natural History in New York City, USA, and the Museum of New Zealand Te Papa Tongarewa (Te Papa Museum) in Wellington, New Zealand).

We also conducted our own field work (though in most cases, unpublished reports were written). Our recent visits to Raivavae began in 2000. Searches for evidence of petrels were conducted mainly at night by listening for the birds at points around the island. Three key listening locations were the circular road, the Route traversière, and the mountain ridge; the ridge was accessed by foot only from the easternmost point of the island up to Mt. Hiro. Up to four digital audio recorders (Song Meter SM4, Wildlife Acoustics;

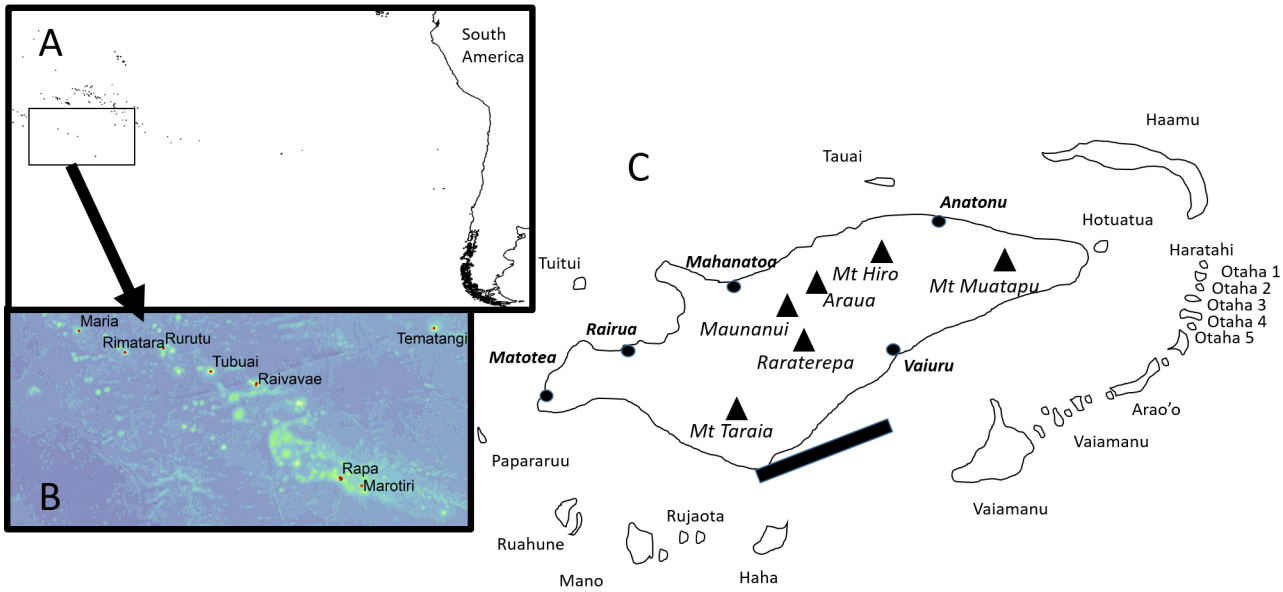

Fig. 1. Geographic names cited in the study. A) The central portion of eastern South Pacific Ocean, showing location of the Austral Islands. B) All the islands of the Austral Islands. C) Raivavae Island and its surrounding islets. The airstrip is shown as a black rectangle, mountain peaks are shown by black triangles, and the five coastal villages are indicated with a black dot.

Maynard, USA) were set simultaneously at various locations along the ridge in 2022 (August, September), 2023 (January, December), and 2024 (January), for a total of 917 hours of recording. They were typically left for at least five days. Depending on month and year, instruments were set to automatically record from sunset to sunrise (August and September 2022), for two periods of four hours each at dawn and dusk, or for only the evening (starting 2 hours before sunset) in December 2023 and January 2024. Islets surrounding Raivavae were visually searched for petrels by day on foot. A few birds were measured when opportunistically caught, and all available relevant information is presented here.

RESULTS

Gould's Petrel *Pterodroma leucoptera*

The first mention of Gould's Petrel *Pterodroma leucoptera* on Raivavae was the discovery on 18–19 December 1989 of about

TABLE 1
Published and unpublished reports of seabirds breeding on Raivavae Island in the eastern South Pacific Ocean, 1921–2023

Year	Date	Author(s)/Observer(s)	Source
1921	24–26 Apr	Beck, R.H., Quayle, E.H., Curtis, A.	Quayle, 1921
1922	08–10 Feb	Beck, R.H., Quayle, E.H., Curtis, A.	Quayle, 1922
1968	25–28 Apr	Lacan, F.	Personal communication
1989	17–19 Dec	Seitre, J. & Seitre, R.	Seitre & Seitre, 1991
1992	16–27 Jul	McCormack, G.	Personal communication
1993	10–23 Feb	Guillemont, A.	Personal communication
2002	18 Nov, 18 Dec	Thibault, J.-C.	Thibault, 2003a, 2003b
2007	18–31 Mar	Gangloff, B., Raust, P., Sanford, G.	Raust, 2007
2008	10–17 Mar	Faulquier, L.	Personal communication
2010	12–16 Apr	Ghestemme, T.	Personal communication
2019	07–11 Aug	Thibault, J.-C., Withers, T.	Personal communication
2019	19–29 Dec	Shirihai, H.	Personal communication
2021	16 Oct, 02 Nov	Tanoi, H. & S.	Tanoi & Tanoi, 2021
2022	11–16 Nov	Butaud, J.-F.	Personal communication
2022	10–19 Aug	David, Y.	Personal communication
2022	12–23 Sep	David, Y.	Personal communication
2023	05–14 Jan	David, Y.	Personal communication

10–15 individuals, audio of which was recorded between 20h00 and 21h00 on 18 Dec on Mt. Hiro (Seitre & Seitre, 1991). One individual was heard at a lower altitude on 19 Dec, but the site could not be located. Recordings were sent to this paper's lead author VB in 1990, who identified *P. leucoptera*, probably the *caledonica* subspecies. The birds were apparently nesting on the slopes of the summit in dense, practically impenetrable vegetation (Seitre & Seitre, 1991). In February 1993, Alain Guillemont caught four individuals at night near the summit, after attracting them with a powerful light. They were photographed, measured (Table 2), and released. These birds were clearly identified as *P. leucoptera*. The display site was on Mt. Hiro's north-facing slope, above the forest. In November and December 2002, in a survey by JCT on the main central mountain chain, no birds were heard or observed. However, early December corresponds to the species' preposital exodus, based on on phenology information from New Caledonia (Bretagnolle et al., 2021). In March 2007, Benoit Gangloff spent several nights on Mt. Hiro and heard Cookilaria petrels but could not catch any. He estimated that several dozen breeding pairs were present. However, given the date, Collared Petrel *Pterodroma brevipes* rather than *leucopetra* may have been heard, especially since there is almost no vocal activity of *leucoptera* in New Caledonia in late March–April (Bretagnolle et al., 2021). On 10 January 2023, a *leucoptera* was caught by YD and at least nine others were seen; an estimated 20 birds were probably present.

We recorded thousands of calls using automated recorders (500 calls per 3 hours, on average) in January 2023, with most heard close to the summit of Mt. Hiro and along the mountain's eastern ridge. Peak vocal activity was recorded in January 2024, with 352 calls/hour on average between 20h00 and 21h00 (see Figs. 2, 3). While no burrow has ever been located, the species is definitely breeding on Mt. Hiro (Fig. 2), either on south-facing slopes in the herbaceous and bushy vegetation below the summit, in the natural forest at around 310 m asl southwest of the summit, or under the ferns that are abundant throughout the fire-prone area below the summit following repeated fires. Based on calling intensity (Fig. 3), the total population is estimated to be 100–250 pairs (Table 3). There

TABLE 2
Measurements of petrels collected or captured on Raivavae Island in the eastern South Pacific Ocean, 1921–2023[a]

Species	Date	Age	Sex	Specimen[b]	Wing	Tail	Culmen	Bill depth	Bill width	Tarsus	Mass	Total length
Pterodroma brevipes	29/07/1992	A		OR025376	218					28.5		
	29/07/1992	A		OR025377	224							
Pterodroma heraldica	29/07/1992	A		OR025378	276							
Pterodroma leucoptera	16/02/1993	A		Alive	235	99	25.5	9	11.4	36.5	199	
	20/02/1993	A		Alive	227	91	24	8		35	210	
	20/02/1993	A		Alive	237	93	26	9		36	210	
	20/02/1993	A		Alive	230	93	26	9		35	180	
Pterodroma neglecta	08/02/1922	A		AMNH191409	294	113.5	31.0	10.7	15.0	36.9		
	29/07/1992	A		OR025379	281							
Puffinus nativitatis	15/12/2002	A		Alive			31.1	8.9		47.6	400	
	15/12/2002	A		Alive			34.3	8.5		46.2	350	
Ardenna pacifica	08/02/1922	Pullus		AMNH191408			20.6	6.5	9.5			110
	10/02/1922	A	M	AMNH191679	295	133	38.2	9.1	16.3	49.7		
	08/02/1922	A	M	AMNH334620	297	140	40	9.5	16.1	50.8		
	11/02/1922	A	M	AMNH334621	300	141	37.5	9.6	15.6	50.8		
	24/11/2002	A		Alive			39.9	9.4		52.5	370	
	24/11/2002	A		Alive			40.5	9.5		51.8	380	
	24/11/2002	A		Alive			39	10		48.8	400	
	02/12/2002	A		Alive			38.5	9.8		48.4		
	04/12/2002	A		Alive			37.8	9.2		49.5	350	
	04/12/2002	A		Alive			40	9.3		51.1	360	
	04/12/2002	A		Alive			38.5	10.3		50.4	360	
	15/12/2002	A		Alive			40.7	9.5		49.5	450	
	15/12/2002	A		Alive			38.8	9.6		49.9	455	

[a] Lengths were measured in millimetres; mass was measured in grams.
[b] Dead specimens are from Museum of New Zealand Te Papa Tongarewa (Te Papa Museum, OR) in Wellington, New Zealand, and the American Museum of Natural History in New York City, USA (AMNH).

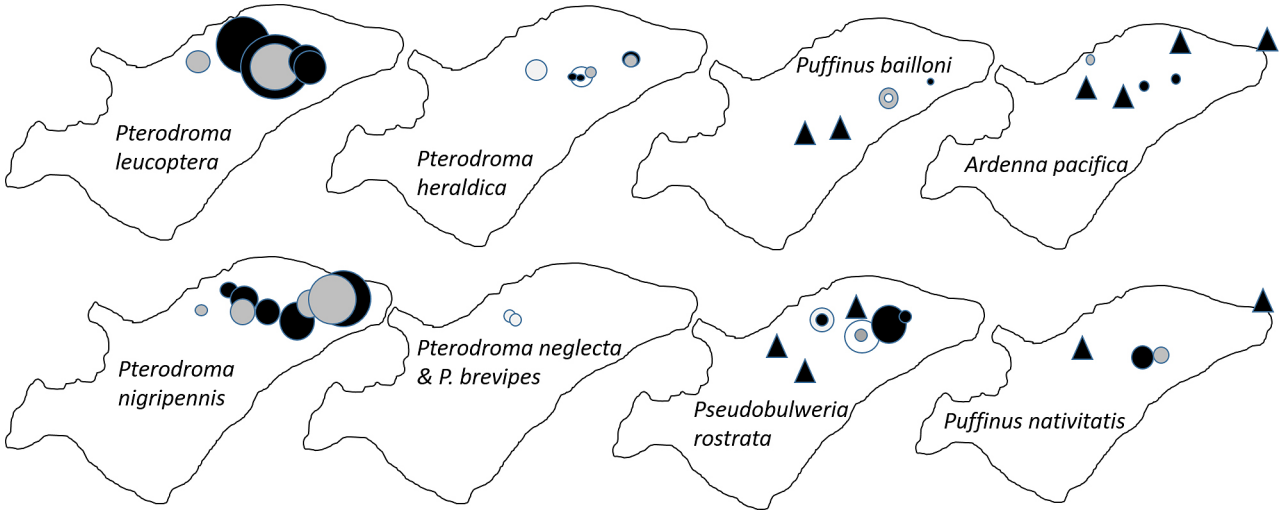

Fig. 2. Breeding distribution of nine species of petrels from Raivavae Island in the eastern South Pacific Ocean, according to vocal activity during the breeding season in 2022–2024. Dot size indicates the number of calls heard per hour, with the smallest dot for a single call and the largest dot for > 250 calls/hour averaged over one month (see Fig. 3). White dots indicate August observations, light grey dots indicate September, dark grey dots indicate December, and black dots indicate January. Historical data (as cited in the main text) are shown with black triangles.

is no reason to believe it is currently declining, at least since 1989, although the arrival of Black Rats *Rattus rattus* may soon become a major threat. However, the precise taxonomic status of Gould's Petrel remains to be ascertained. The closest breeding population of this species is 4,800 km away in New Caledonia, but individuals in the Raivavae population also seem slightly larger than *Pterodroma leucoptera caledonica* (Table 2). From the scant data that exist, the timing of breeding seems to be similar to that in New Caledonia, with laying taking place in late December–January and fledging presumably in late April (Bretagnolle et al., 2021).

Collared Petrel *Pterodroma brevipes*

Both the taxonomy and breeding distribution of the Collared Petrel has been subject to changes arising from recent information (Bretagnolle & Shirihai, 2010; Tennyson et al., 2012). The situation

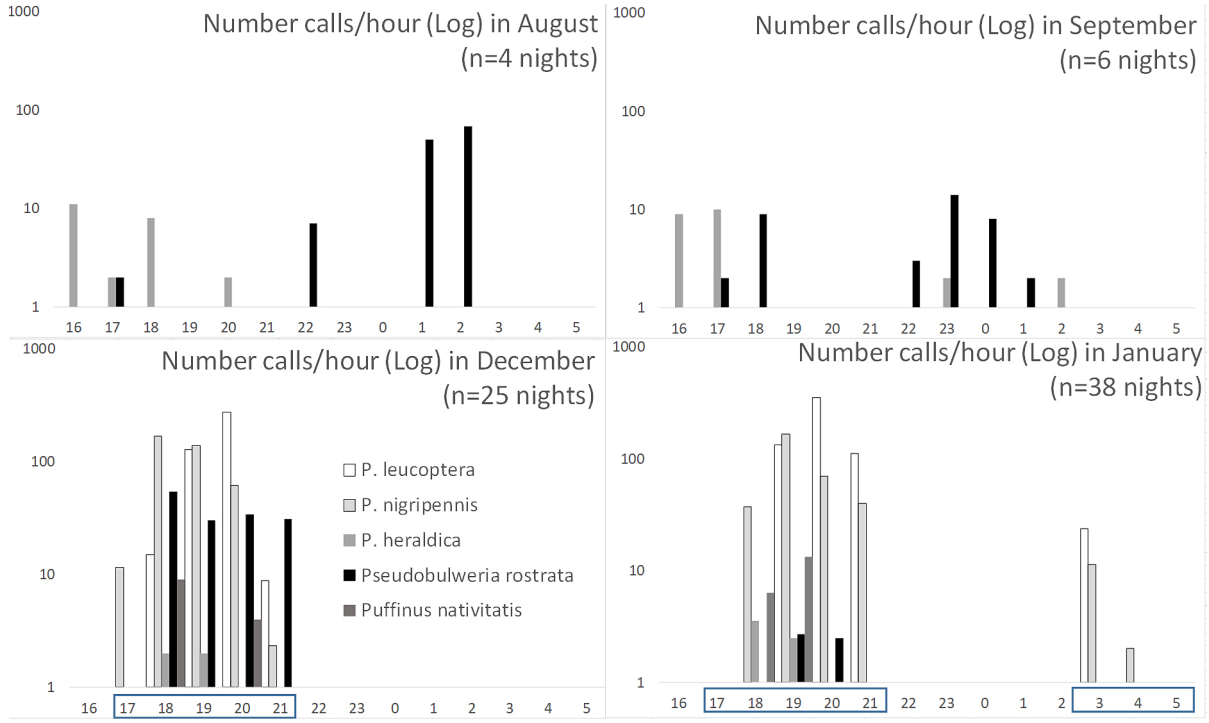

Fig. 3. Histograms showing the average number of petrel calls heard per hour on Raivavae Island in the eastern South Pacific Ocean during the breeding season in 2022–2024. Data is shown according to hour (x-axis), month (one month per panel), and species (bar colour; "P." indicates *Pterodroma*). On the two lower graphs, the rectangles on the x-axis indicate the hours where calls were recorded.

TABLE 3
Petrel species breeding on Raivavae Island in the eastern South Pacific Ocean, with numbers and their presumed or established breeding timetables

Species	First discovered	Estimated breeding population (pairs)	Distribution range on Raivavae Island	Breeding phenology
Pterodroma leucoptera	1989	100–250	Central ridge (Mt. Hiro), western and southern slopes	Laying January, fledging May
Pterodroma brevipes	1992	< 50	Mt. Hiro	Fledging July
Pterodroma nigripennis	2019	50–100	Primarily on eastern ridge, secondarily on central ridge	Summer breeder
Pterodroma heraldica	1992	5–10	South slopes of central ridge	Winter breeder
Pterodroma neglecta	1922	1–2	Central ridge, coral islets	Unknown
Pterodroma ultima	1968	100–150	On at least 11 of the 27 coral islets; possibly on main island	Fledging September
Pseudobulweria rostrata	2002	10–25	Central ridge, but also on western summits	Winter breeder
Ardenna pacifica	1922	200–250	6 different places on main island, Hotuatua Islet	Laying December
Puffinus nativitatis	2002	10–15	Hotuatua Islet, possibly Mt. Hiro	Laying November
Puffinus bailloni	1989	10–25	Mt. Raraterepa	Unknown
Nesofregetta fuliginosa	Unknown	Unknown	Oral testimony only	Unknown

on Raivavae has been particularly unclear, partly because the taxonomic distinction between *brevipes* and *leucoptera* is relatively recent (Imber & Jenkins, 1981). *P. brevipes* was unknown on Raivavae until July 1992, when Gerald McCormack visited the island and found several remains of petrels on the slopes of Mt. Hiro. Of these, the wings of two dead birds were found on the west-facing slopes of the main south ridge. They were found scattered with other petrel corpses in an area blackened by an extensive fire; the birds had been killed by domestic cats *Felis catus* (G. McCormack, personal communication, 2002). The specimens are in the Te Papa Museum (Table 2). These remains proved to be *P. brevipes*, based on the short tarsus length and underwing primary pattern. Permission was granted to VB to obtain a tissue sample from one of the birds, and genetic sequencing confirmed it to be *brevipes* (Iglesias Vasquez, 2016). The bird remains were found in July, which, although early, is a possible fledging time of *brevipes*. Moreover, fledglings are known to be particularly attracted to the light of fires. Calls of *brevipes* were recorded on 19 September 2022 at 18h00 on top of Mt. Hiro (Fig. 2); these were probably fledglings, given the date. However, in the absence of any other evidence, it is difficult to know if *brevipes* is breeding on Raivavae.

Black-winged Petrel *Pterodroma nigripennis*

The Black-winged Petrel *Pterodroma nigripennis* was unknown on Raivavae until December 2019, when HS discovered a small breeding colony on the southeastern corner of the island, with a display site over the ridge (Fig. 2). Based on the birds' behaviour, the nests were assumed to be on the dense vegetated slope. During 20–29 December 2019, between 6 and 18 birds displayed late in the day and up to 30 displayed during the night, suggesting a breeding colony of 20–40 pairs. In October and November 2021, the site was visited again but no petrel was seen or heard (Tanoi & Tanoi, 2021). In January 2023, *nigripennis* was found further to the west of the central mountain ridge and up to Mt. Hiro, based on automated audio recordings. The number of calls recorded (a maximum of 2,490 calls in three hours, and regularly over 1,000) suggests that the breeding population is likely to be 50–100 pairs (Table 3). In December 2023 and January 2024, an average of 170 calls/hour could be counted (Fig. 3).

Herald Petrel *Pterodroma heraldica*

The Herald Petrel *Pterodroma heraldica* had never been recorded on Raivavae, including in a 1984 study (Holyoak & Thibault, 1984), until about 12–20 non-breeding birds were seen by Gerald McCormack on 16 and 27 July 1992. Light-phase birds were observed flying over the centre of the island. At least one individual was photographed by Alain Guillemont in February 1993. Three individuals were seen by Benoit Gangloff at 17h00 on Mt. Hiro on 19 March 2007 (Raust, 2007); later in March, he saw eight individuals flying, of which two landed on slopes covered with ferns between the central mountain ridge and the village of Vaiuru (Fig. 1). At least two pairs were seen by Lucie Faulquier in March 2008 displaying and landing on Mt. Hiro. In 2022–2024, we observed and recorded Herald Petrels, with the highest numbers in August and September (Fig. 2). This is an expected pattern, given the winter breeding of the species on Raivavae. However, we recorded audio evidence of one or two birds in December 2023 and in January 2024. Only light-phase birds have been encountered so far (Flood et al., 2022). The breeding population is estimated at 5–10 pairs (Table 3), restricted to the southern slopes of the central mountain ridge (Fig. 2).

Kermadec Petrel *Pterodroma neglecta*

In February 1922, a light-phase Kermadec Petrel *Pterodroma neglecta* was collected on Raivavae when flying on a ridge at 280 m asl by the Whitney South Sea Expedition (WSSE) of the American Museum of Natural History (Holyoak & Thibault, 1984; Quayle, 1921). Another individual was seen the following day on a ridge at around 18h30, but although it resembled *neglecta*, it appeared to be too small to belong to this species (Quayle, 1922). On 19 December 1989, one bird was

observed in flight near Mt. Hiro's great cliff (Seitre & Seitre, 1991) and one dead bird, killed by a cat, was found in July 1992 on the west-facing slope of the main south ridge (G. McCormack, personal communication, 2002). This specimen is at Te Papa Museum (Table 2). Despite multiple surveys on the ridges and near the cliffs of the main summits, Kermadec Petrel was not observed on visits in 2002, 2007, or 2008 (Raust, 2007; Thibault, 2003b). In August 2019, one pair was spotted in display on Otaha 4 (one of the coral islets east of Raivavae). In November 2022, two birds were seen in a flight display above coral islets south of the island. On 15 September 2022, a single calling bird was found on the eastern slopes of the island (Table 1, Fig. 2). Clearly this gadfly petrel is rare on Raivavae, and although breeding is likely but unconfirmed, the total population size is probably less than five pairs.

Murphy's Petrel *Pterodroma ultima*

The Murphy's Petrel *Pterodroma ultima* was reported by François Lacan during his visit to Raivavae on 25–28 April 1968. On the southern slopes of Mt. Manui (Maunanui), he reported two pairs actively engaged in flight display at sunset. However, misidentification with Christmas Shearwater *Puffinus nativitatis* is more likely, since Murphy's Petrel is restricted to coral islets. Murphy's Petrel was then recorded in February 1993 by Alain Guillemont. The species is said to be common on coral islets, especially in September–October, when locals used to collect fledglings for food (oral testimony collected by JFB). In August 2019, the species was found on the following islets (Fig. 1, Table 1): Papararuu (one adult in flight, two chicks), Otaha 1 (one incubating bird, at least one other bird), Otaha 2 (one incubating bird), Otaha 3 (one pair displaying, one incubating bird, two chicks), Otaha 4 (estimate of at least 50 pairs), and Otaha 5 (one pair in flight display); the breeding population was estimated to exceed 100 pairs on the island. In September 2022, the species was observed again on Papararuu. In November 2022, it was observed breeding on Otaha 1 (12 pairs), Otaha 2 (10 pairs), Otaha 3 (6 pairs), Haratahi main (2 pairs), Haratahi north (a satellite islet of Haratahi, 1 pair), and Arao'o (1 pair). It appears that *P. ultima* is breeding on at least 11 of the 27 coral islets. The total breeding population is over 100 pairs, perhaps reaching 150 (Table 3).

Tahiti Petrel *Pseudobulweria rostrata*

The Tahiti Petrel *Pseudobulweria rostrata* had never been recorded on Raivavae until 09 December 2002, when a single individual was heard at night. Several calls were subsequently heard close to Mt. Maunanui, and then again at the bottom of Mt. Raraterepa by JCT. The species was found at Mt. Hiro (2–3 birds) on 19 March 2007 and again on 22 March (Raust, 2007). On 10 August 2019, at least two birds were heard at twilight in forested vegetation below the cliff above the village of Anatonu. In 2022–2024, calls were recorded in August, September, December, and January (Fig. 2, 3). The maximum number of calls (~150) was heard during the night of 14 August 2022 close to Mt. Hiro on the central mountain ridge, but solitary calls were heard all along the ridge (Fig. 2). No nest has ever been found, but breeding is extremely likely though the population size is probably small, perhaps about 10–25 isolated pairs.

Wedge-tailed Shearwater *Ardenna pacifica*

The Wedge-tailed Shearwater *Ardenna pacifica* has been known to breed on Raivavae since the 1922 WSSE, when Ernest Quayle collected an adult and two chicks at altitude in February (Quayle, 1922). The species is also present on the eastern slope of Hotuatua Islet (40–100 pairs) and on the Pahaoa ridge above Anatonu, where three small colonies totalling 30 pairs were found in 2002 (Table 1). On 20 March 2007, breeding was confirmed on Hotuatua in high density (Raust, 2007), estimated at 50–100 pairs. The density of the burrows despite the small size of the islet may suggest an even higher total population. Recently, feral pigs *Sus scrofa* and feral goats *Capra* spp. have reached the islet, and this could pose a threat to shearwaters. No Wedge-tailed Shearwaters were found on Mt. Hiro itself (although there are possible colonies at the foot of the cliffs on the northern coast), and calls by individuals or pairs were recorded at various sites of the crest ridge (Fig. 2). Overall, the species is known to breed on only Hotuatua, as well as on Raivavae in at least six locations (Mt. Araua, Mt. Maunanui, Mt. Raraterepa, and the villages of Anatonu, Matotea, and Vaiuru), all colonies being on wooded slopes between 20 and 200 m asl. All nests observed in 2002 were in burrows of varying depths (ranging from a few centimetres to over two metres) and located at the foot of boulders, *Casuarina* trees, or shrubs (hibiscus, guava). Between 24 November and 05 December 2002, no eggs were found, while most nests had incubating birds as of 15 December. Three pairs were recorded in burrows but with no egg in November 2022, while six out of ten occupied burrows had eggs in January 2023. The total breeding population is probably around 250 pairs of which 100 are on Hotuatua Islet.

Christmas Shearwater *Puffinus nativitatis*

The Christmas Shearwater had not previously been reported on Raivavae, but it seems that no observer had visited Hotuatua Islet before 2002. In that year, three nests were found with incubating birds on 25 and 26 November, and an adult was recorded with a chick on 15 December (Table 1). In March 2007, two pairs were found on the islet, and the number of pairs was estimated to be 10 to 20 (Raust, 2007). In October and November 2021, several dozen pairs were observed (Tanoi & Tanoi, 2021). At least four pairs were found in September 2022 and January 2023, and three pairs were found in burrows in November 2022. On Raivavae, one and then two calling birds were heard on Mt. Hiro on 12 March 2008. Pairs were also recorded on ridge crests in at least two sites in December 2023 and January 2024 (Fig. 2). The total breeding population on Raivavae is 10–15 pairs.

Tropical Shearwater *Puffinus bailloni*

A Tropical Shearwater *Puffinus bailloni* was reported by Seitre & Seitre (1991) on 18 December 1989: 'one call heard once just after dark at the pass of the *Route traversière'*. This species probably also nests on the Raraterepa massif, as isolated birds and a group of calling birds were heard at the foot of Mt. Raraterepa on the evenings and mornings of 09 and 10 December 2002. On 14 August 2022, a single bird was heard on the central mountain ridge above Anatonu. The total population is probably quite small, less than 25 pairs, in the centre of the island (Fig. 2).

DISCUSSION

The petrels of Raivavae

No storm petrel has ever been recorded breeding on Raivavae (though oral testimony of Polynesian Storm Petrel *Nesofregetta*

fuliginosa to J.-F. Butaud in 2010 indicates possible presence; Table 3), even though both *Fregetta* and *Nesofregetta* storm petrels are breeding in significant numbers on nearby Rapa (Flood et al., 2021). No subfossils or recent bones of storm petrels have been found on Raivavae either, although it is likely that storm petrels used to be present, as they were on many other islands of the central Pacific (Steadman, 2006). However, ten species of petrels have been found breeding on Raivavae to date, and these recent discoveries make the island unique in its species richness. It is remarkable that seven of these species have been discovered on Raivavae since 1989, and three after 2000. Such findings are not, however, peculiar to Raivavae. The first records of Tahiti Petrels in the Gambier Islands are from the mid 1990s, though they were previously unknown in the area (Thibault & Bretagnolle, 1999), and subfossil bones were recently found as well (Rigal et al., 2018). Although these discoveries on Raivavae are clearly attributable to a lack of visiting ornithologists, recent colonization is certain for Black-winged Petrel on Raivavae and on the islet of Motu Nui just southwest of Rapa Nui (Rapa Nui is also known as Easter Island; Plaza et al., 2021). It seems clear that the WSSE missed most of the breeding petrel species since they only found two species (Quayle, 1921, 1922), but the timing of their visit (February and April) may explain this in part.

Compared to the other Austral Islands, Raivavae harbours a diverse seabird community despite its small size. On Rapa, there are seven breeding petrel species (Flood et al., 2021; Thibault & Varney, 1991). In the Gambier Islands, there are also seven breeding petrel species (Thibault & Bretagnolle, 1999). Rapa Nui, along with Ducie, Henderson, Oeno islands in the Pitcairn group, all have fewer than 10 breeding petrel species (Brooke, 2004; Plaza et al., 2021). Therefore, Raivavae, with no less than six *Pterodroma* gadfly petrels breeding in sympatry, is special—the only other island in the world with six *Pterodroma* species breeding in sympatry is Motu Nui (Rapa Nui; Plaza et al., 2021, 2023). However, some petrel species have already gone extinct on these islands, e.g., Henderson Island (Wragg, 1995) and Rapa (Tennyson & Anderson, 2012). This means that what we see today is only an indication of past species diversity, so it is difficult to make any biogeographic comparison. Despite this limitation, the location of Raivavae and its mix of subtropical and tropical species may have led to its increased species richness: both Gould's Petrel and Collared Petrel occur together, and Raivavae is the southern limit for two tropical/equatorial species (Tropical Shearwater and Tahiti Petrel) and one subtropical species (Herald Petrel); all three of these species are absent from Rapa. In fact, not only is Raivavae rich in seabirds, but so are the Austral Islands in general: with 23 of the 29 species known to breed in French Polynesia (Raust, 2015), this is the most species-diverse archipelago in French Polynesia, if not the entire tropical Pacific.

One reason for this diversity may be that Black Rats were absent in the area until 2010, including on Raivavae. Nonetheless, all petrel species now occur in low to very low numbers. Such numbers are certainly attributable to the presence of invasive predators (mainly cats, but also pigs), which limit petrel colonies to islets or cliffs when they are present. The total breeding petrel population is fewer than 1,000 pairs. However, a significant population of Murphy's Petrel is breeding on Raivavae. Another species breeding in notable numbers is Gould's Petrel, though the species' exact taxonomic status is still pending.

Raivavae compared to the other Austral Islands

There are seven islands in the Austral Islands. West of Raivavae are Tubuai, Rurutu, Rimatara, and Maria (Fig. 1), and even less is known about their breeding petrel species than was known about those on Raivavae. Table 4 highlights the few species known to breed there (six species on Rurutu and four on Tubuai). Of these, only the Collared Petrels on Rurutu appear to be of significant conservation importance. Almost all these data were collected only recently. Rurutu has been monitored over the last 24 months by one of the authors (YD), who has been living there and has conducted many surveys at night. This is not the case on Tubuai, where most visits have been during the day. Only Kermadec Petrel has been observed on Rimatara, and no petrel has ever been detected either recently or in the past on Maria (a low island). Both Rurutu and Tubuai have cliffs (like Raivavae and Rapa) while Rimatara and Maria do not, and this certainly helps to explain why petrels have survived on the former islands despite the presence of invasive mammals. However, the population size of these petrels on Tubuai and Rurutu is extremely low, even lower than on Raivavae (Table 4).

Threats and conservation

A number invasive species have become established on Raivavae and associated islets. The Polynesian Rat *R. exulans* has been present for a long time on the island, probably introduced by earlier Polynesians. Black Rats were absent over the last 25 years despite the presence of a wharf, until their first detection in 2010, when one was caught by TG. More Black Rats were found in 2023 on Raivavae and in 2022 and 2023 on the islet of Hotuatua. The presence of rats, whatever the species, constitutes a major threat to this unique petrel community. Feral cats are present on the main island, possibly in high numbers, as well as on some of the islets. One cat observed on the islet of Haha on 06 December 2002 (J.-Y. Meyer, personal communication, 2010) had been deliberately introduced to control rats. The presence of goats *C. hircus* (about 100 individuals in 2002, and the same number counted in 2023) is of concern. They have been observed with the following distribution across Raivavae's peaks (Taraia 15, Mt. Maunanui 5, Mt. Araua/Mt. Hiro > 50, Mouatapu-Turivao 25, Matotea 20) and on Hotuatua (at least one in 2022). Goats are a major problem because of their effects on the vegetation. Whereas mountain vegetation can protect breeding sites, human inhabitants used to regularly burn these areas, especially the fern-covered slopes, giving goats easy access to feed on endemic plants and make trails, which then opens tracks for cats to visit petrel breeding sites. Lastly, pigs were intentionally introduced recently on Hotuatua—at least 11 individuals were counted in November 2022 and January 2023.

The presence of these invasive mammals and their abundance (at least for goats, cats, and pigs locally) is a major threat and limiting factor for petrel populations. Conservation actions should thus prioritize the eradication of these introduced species, at least at small sites such as the islets surrounding the main island (e.g., the pigs, rats, and goats on Hotuatua). Goat eradication or control on the main island should be discussed with local authorities. A possible solution to get local support would be to provide funding to fence animals instead of letting them roam freely on the island. Cat control on Mt. Hiro might also be considered, given the importance of this locality as a breeding site for several petrel species. In the past, the local community used to collect petrel fledglings (notably Murphy's Petrel) or harvest chicks in March before they fledge,

TABLE 4
Numbers of petrels breeding in the Austral Islands in the eastern South Pacific Ocean, on islands other than Raivavae (this paper) and Rapa and Marotiri (see Flood et al., 2021; Withers et al., 2025)

	Island				
Species	**Maria**	**Rimatara**	**Rurutu**	**Tubuai**	**Sources**
Pterodroma neglecta	-	Observed 10 Dec 1989 flying over the island		1 dead bird 28 Jul 1975 misidentified (Thibault & Cibois 2005)	Holyoak & Thibault, 1984; Seitre & Seitre 1991
Pterodroma heraldica	-		Found May to September, Breeder (5–10 pairs), summit; 4 birds max		Present study
Pterodroma ultima	-		1 pair in flight observed July 2007	1 seen flying in the lagoon late July 1975 and in 2003	Holyoak & Thibault, 1984; Raust, 2015
Pterodroma brevipes	-		Audio recording May 2022 (5–10), summit; small colony, 10–25 pairs		Present study
Pseudobulweria rostrata	-		Probable breeder, heard several times, summit	Possible breeder, heard 2012	Rurutu observation by YD; present study
Ardenna pacifica	-			Small colony on Motu Ofai	B. Fontaine, personal communication, 2003
Puffinus bailloni	-		Observed between May and October, breeder (5–10 pairs), coastal cliff (2 sites)		Present study
Puffinus nativitatis	-		Observed September 2022	1 pair on Motu Ofai (November 2003)	B. Fontaine, personal communication, 2003; present study

but these practices are declining today. However, to mitigate any potential impacts from overharvesting, it would be valuable to organise public meetings with the island authorities to share information about protecting seabird colonies via rahui (i.e., taboo or limited areas for harvesting). These meetings could also provide a way to communicate about invasive species and biosecurity, so that the islets that are still pest-free can remain so, on this, the most petrel-rich site remaining in the tropical Pacific.

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AUTHOR CONTRIBUTIONS

VB wrote a first draft. YD and VB analysed acoustic data. TG, YD, JFB, TW, HS, and JCT collected the data. TG and TW organised recent fieldwork campaigns. JCT provided much of the unpublished information. All authors contributed to the writing and approved the final version.

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