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Author: Schmidt, Jan-Uwe

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New data on elevational distribution, abundance and nesting of birds on Bougainville Island, Papua New Guinea

by Jan-Uwe Schmidt

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Summary.—Bougainville is a mountainous tropical island in Melanesia, reaching 2,712 m at Mt. Balbi, the highest elevation in the tropical South Pacific outside of New Guinea. In 1972, J. Diamond climbed the active stratovolcano to *c.*2,000 m and provided detailed information on its montane avifauna. Fifty years later, the elevational distribution of birds on Mt. Balbi was resurveyed in November 2022, this time to the summit. Twenty-nine of the 37 bird species for which Diamond had provided elevation data were found at higher elevations than 50 years ago. In total, 35 species were found at new max. elevations.

Bougainville is the largest island in the Solomon Islands and although politically it belongs to Papua New Guinea, biogeographically it is part of the Solomons. The island has a total area of about 8,700 km² and reaches 2,712 m at its highest point, the active stratovolcano Mt. Balbi. The mountain is located in central-northern Bougainville and is part of a range that extends from Mt. Loloru in the south, through the Crown Prince Range and the Bagana-Billy Mitchell volcanic complex in the centre, to the Emperor Range in the north. Elevations along the chain are all in excess of 900 m, broken only by a 6–12 km-wide gap of lower elevations (*c.*700 m) in the Rotokas area of central Bougainville. South-west of this gap is the Keriaka plateau, an uplifted coral limestone karst area, reaching *c.*1,400 m (Blake & Miezitis 1967).

Melanesia in general is a biodiversity hotspot and its islands host many restricted-range species (Mayr & Diamond 2001). As predicted by its size, Bougainville boasts rich biodiversity and its avifauna includes many endemic and restricted-range species, confined to either the island itself or the East Melanesia Biodiversity hotspot (CEPF 2012). In total, Bougainville hosts 115 breeding bird species, of which 16 are confined to the mountains, and supports the richest montane bird species assemblage in the Solomon Islands. Of these 16 montane species, seven are endemic to Bougainville (*sensu* Gill *et al*. 2024). Mt. Balbi forms part of the Kunua Plains and Mt. Balbi Key Biodiversity Area (CEPF 2012), making it a potentially important site for biodiversity conservation.

Bougainville was originally covered entirely by dense rainforest. Whilst the lowlands and uplands up to about 800 m are used by a growing human population, montane forest is largely intact and starts at *c.*600–700 m (Schodde 1977, Hadden 2004), extending to *c.*1,200 m, where it gradually transitions into upper montane cloud forest. Lower montane forest is characterised by mid-height trees, climbers and epiphytes, whereas cloud forest comprises mainly palms, ferns and epiphytes (Hamlin 1928, Schodde 1977, Hadden 2004). The upper limit of upper montane forest was observed on Mt. Balbi at *c.*2,100 m. Above this, wet, stunted, moss-covered elfin forest (Fig. 1; Hamlin 1928) occurs to the treeline, which surrounds the summit region at 2,200–2,500 m. Beyond the treeline, large tussocks of a sword-leaved grass-like plant prevail up to the highest peaks, although there are barren areas due to volcanic activity (Branch 1965; pers. obs.).

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Figure 1. Elfin forest with stunted growth at *c.*2,430 m, Mt. Balbi, Bougainville (Jan-Uwe Schmidt)

During the Pleistocene, Bougainville and the smaller northern island of Buka, along with Choiseul, Isabel, Nggela (formerly Florida) and possibly Guadalcanal, formed a single large island, usually referred to as Greater Bukida (Mayr & Diamond 2001). Even then, Bougainville, at the northern end, and Guadalcanal, at the southern tip of Greater Bukida, were separated by >500 km of intervening lowland or hill country, reaching max. elevations of 1,120 m. While lowland avifaunas within this island chain are broadly similar, its montane species are rather different (Mayr & Diamond 2001).

The history of ornithological exploration on Bougainville was outlined by Schodde (1977) and Hadden (2004). A. S. Meek was the first Western naturalist to work on Bougainville, in 1904 and 1907/08 (Parker 1967). Meek (1913: 183) mentioned having made 'on one or two occasions […] voyages from the coast up to the mountains' in north Bougainville 'but saw nothing worth stopping for'. Meek's specimens of Bougainville Moustached Kingfisher *Actenoides bougainvillei* were collected at a camp apparently near the coast south of Kieta (Parker 1967). However, the circumstances of their acquisition were not described and, given the species' montane distribution on Bougainville and that of its congener on Guadalcanal, it seems likely that Meek obtained his specimens in the mountains of the Crown Prince Range.

Members of the Whitney South Sea Expeditions (WSSE) made the first systematic collection of montane birds at Kupei, central Bougainville, in the hinterland of Arawa along a trail to present-day Panguna (Hamlin 1928). They reached *c.*1,675 m, provided elevational ranges for several species (Table 1) and recognised the presence of birds restricted to the mountains of Bougainville for the first time. Hamlin himself even climbed Mt. Balbi from its western side, but did not report on the birdlife there (Hamlin 1928, 1929), although he collected at least two specimens of Island Thrush *Turdus poliocephalus* (Mayr 1941).

In the 1930s and 1940s, there were a few minor reports on lowland or coastal birds (see Hadden 2004 for references). In the 1960s and 1970s, two studies of montane birds were

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TABLE 1

Elevational data from this study compared with previous data. Notes: (1) *n* = total number of records, not the number of (different) individuals or territories; (2) elevations covered by the studies are given at the head of the table; (3) * species with new upper elevational range records, ° species with new lower limits; (4) species with a montane distribution on Bougainville are denoted in bold type; (5) data in Dutson (2011) and Gregory (2017) may relate to other islands due to the broader focus of their field guides.

Species	*n*	this study	Hamlin (1928)	Diamond (1975)	Schodde (1977)	Hadden (1981)	Hadden (2004)	Dutson (2011)	Gregory (2017)	Woxvold & Novera (2021)
		0–2,712 m	0–1,675 m	0–1,950 m	0–1,500 m	0–1,600 m	0–2,000 m			0–1,765 m
Melanesian Megapode *Megapodius eremita*	1	41	--	--	--	0–600	0–1,000	0–1,500	0–1,500	--
*Glossy Swiftlet *Collocalia esculenta*	17	6–2,455	0–>1,675	0–≥1,950	200–1,500	0–1,600	0–max	0–max	0–max	--
White-rumped Swiftlet *Aerodramus spodiopygius*	1	7	--	--	--	0–1,600	0–1,600	--	--	--
Uniform Swiftlet *Aerodramus vanikorensis*	4	7–37	--	--	0–1,500	0–'Panguna'	0–1,600	0–max	--	--
Pacific Koel *Eudynamys orientalis*	10	11–771	--	--	0–600	--	--	0–800	0–1,500	--
*Brush Cuckoo *Cacomantis variolosus*	35	11–1,999	0–>1,675	0–≥1,200	once near the coast	0–1,200	0–max	0–1,600	0–1,800	--
*Mackinlay's Cuckoo-Dove *Macropygia mackinlayi*	49	167–2,100	0–>1,675	--	0–700	(0–) 200–800 (–1,500)	200–800 (–1,500)	0–1,600	--	0–1,480
Crested Cuckoo-Dove *Reinwardtoena crassirostris	15	919–1,999	1,050–>1,675	--	once at *c.*270	>200	--	(0–) 500–900 (–1,500)	>1,100	--
Stephan's Emerald Dove *Chalcophaps stephani*	1	27	0–600	--	--	200–700	--	0–750	0–1,200	--
Superb Fruit Dove *Ptilinopus superbus*	12	15–1,251	0–900	--	250–300	0–800	0–800	0–1,250	0–800	--
*°**Yellow-bibbed Fruit Dove *Ptilinopus solomonensis***	72	551–2,445	900–>1,675	900–≥1,950	700–1,500	>800	--	> (600) 700	>600	--
*Claret-breasted Fruit Dove *Ptilinopus viridis*	37	6–1,260	0–900	--	0–700	0–800	0–800	0–950	0–800	--
*Red-knobbed Imperial Pigeon *Ducula rubricera*	79	6–1,260	0–900	--	0–300	0–300	0–800	0–500 (–1,250)	--	to 850
*Island Imperial Pigeon *Ducula pistrinaria*	84	0–1,036	0–900	0–600	0–300	0–600	0–730	0–600	--	to 730
Pale Mountain Pigeon *Gymnophaps solomonensis	3	1,729–2,452	900–>1,675	750–≥1,950	700–1,500	>750	600–max	(0–) 500–1,565	(0–) 500–1,565	--

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Species	*n*	this study	Hamlin (1928)	Diamond (1975)	Schodde (1977)	Hadden (1981)	Hadden (2004)	Dutson (2011)	Gregory (2017)	Woxvold & Novera (2021)
		0–2,712 m	0–1,675 m	0–1,950 m	0–1,500 m	0–1,600 m	0–2,000 m			0–1,765 m
Australasian Swamphen *Porphyrio melanotus*	1	2	--	0–600	--	0–800	0–800	0–600	0–1,800	--
Osprey *Pandion haliaetus*	4	0–7	--	--	0–25	'confined to the seacoast'	lowland	coastal	--	--
Pacific Baza *Aviceda subcristata*	2	6–11	0–1,050	--	--	0–750	0–750	0–800	0–1,300(–1,700)	--
Variable Goshawk *Accipiter hiogaster*	1	535	0–1,050	0–900	0–600	0–900	0–900	0–800	--	--
Pied Goshawk *Accipiter albogularis*	3	6–816	1,050–>1,675	0–1,800	0–450	>0	0–750	0–1,800	0–1,800	--
Brahminy Kite *Haliastur indus*	6	0–801	0–600	--	0–700	0–'Panguna'	0–800	0–1,000	0–2,300	--
Solomons Sea Eagle *Icthyophaga sanfordi*	1	7	0–>1,675	0–1,200	0–1,500	0–'central mountain chain'	0–max	0–1,500	0–1,500	--
West Solomons Owl *Athene jacquinoti*	9	41–1,999	0–600	--	0–1,500	0–1,500	0–max	0–2,000	0–2,000	--
Fearful Owl *Asio solomonensis*	1	1,251	--	--	--	--	0–2,000	0–2,000	0–2,000	--
*Papuan Hornbill *Rhyticeros plicatus*	24	6–1,709	0–>1,675	--	0–1,500	0–1,500	0–max	0–1,100 (–1,500)	0–1,500	--
Oriental Dollarbird *Eurystomus orientalis*	2	16–37	--	--	0–600	0–800	0–800	0–900	0–1,400	--
Ultramarine Kingfisher *Todiramphus leucopygius*	10	7–591	0–1,050	--	0–700	0–700	0–700	0–700	0–700	--
*Melanesian Kingfisher *Todiramphus tristrami*	31	11–1,543	0–1,050	--	0–600	0–'Panguna'	0–700	0–1,500	0–1,500	0–1,420
*Solomons Cockatoo *Cacatua ducorpsii*	106	0–2,433	0–>1,675	0–1,800	0–700 (–1,500)	0–'high mountains'	0–max	0–700 (–1,800)	0–1,700	--
°**Red-breasted Pygmy Parrot *Micropsitta bruijnii***	1	534	--	--	only one record at *c.*1,300	>1,200	>1,200	(500–) 720–max	>700	--
*Papuan Eclectus *Eclectus polychloros*	12	0–1,251	0–1,200	--	0–250	0–800	0–800	0–1,150	0–1,100	--
*Song Parrot *Geoffroyus heteroclitus*	1	1,005	0–600	--	0–600	0–600	0–600	0–900 (–1,760)	0–900	--

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Species	*n*	this study	Hamlin (1928)	Diamond (1975)	Schodde (1977)	Hadden (1981)	Hadden (2004)	Dutson (2011)	Gregory (2017)	Woxvold & Novera (2021)
		0–2,712 m	0–1,675 m	0–1,950 m	0–1,500 m	0–1,600 m	0–2,000 m			0–1,765 m
Duchess Lorikeet *Charmosynoides*	1	1,005	--	0–1,350	0–750	0–1,350	0–1,350	0–1,350	0–1,350	0–1,480
*Meek's Lorikeet *Vini meeki*	2	1,981–2,325	900–>1,675	0–1,800	300–1,500	300–1,500	300–2,000	>1,000	>1,000	--
Cardinal Lory *Pseudeos cardinalis*	45	0–1,077	0–1,200	0–830	0–750	0–830	0–2,000	0–1,200	0–830	--
Coconut Lorikeet *Trichoglossus haematodus*	57	6–1,923	0–1,200	--	0–1,000	0–1,000	0–2,000	0–1,900	0–2,440	--
Bougainville Honeyeater *Stresemannia bougainvillei	1	1,999	750–>1,675	recorded only at 1,950	700–≥1,500	700–1,950	700–1,950	700–1,950	700–1,950	--
*Red-capped Myzomela *Myzomela lafargei*	19	846–2,433	0–>1,675	0–≥1,800	250–1,500	0–1,800	0–2,000	0–2,000	0–2,000	--
Barred Cuckooshrike *Coracina lineata*	1	534	0–900	0–1,100	250–1,000	0–1,100	0–1,000	0–900 (–1,200)	0–900 (–1,200)	--
White-bellied Cuckooshrike *Coracina papuensis*	7	7–737	--	0–1,100	0–700	0–1,100	0–800	0–900 (–1,400)	0–1,450	--
Solomons Cuckooshrike *Edolisoma holopolium*	1	903	--	0–760	400–700	0–800	0–800	0–1,200	0–1,200	0–800
Grey-capped Cicadabird *Edolisoma remotum*	5	622–1,103	--	--	0–1,000	0–1,000	0–1,000	0–1,400	0–1,000	0–1,440
Oriole Whistler *Pachycephala orioloides*	9	974–1,293	0–900	600–900	700–1,000	600–1,200	600–1,200	600–1,200 (–1,500)	600–1,200 (–1,500)	--
Bougainville Whistler *Pachycephala richardsi	19	1,158–2,433	900–>1,675	up to ≥1,750	1,200–1,500	1,200–1,750	1,200–max	1,200–1,750	(900–) 1,200–1,750	--
Willie Wagtail *Rhipidura leucophrys*	15	0–243	--	--	0–200	--	0–800	0–800	0–2,800	--
*Cockerell's Fantail *Rhipidura cockerelli*	3	978–1,260	0–900	0–950	0–1,000	0–1,000	0–1,000	0–1,150	0–1,150	to 1,200
Bougainville Fantail *Rhipidura drownei	11	1,251–2,122	900–>1,675	830–≥1,600	(900–) 1,200–1,500	>800	900–max	> (700–) 900	>900	--
*Solomons Rufous Fantail *Rhipidura rufofronta*	6	783–1,284	0–900	0–830	700–1,200	0–1,200	0–1,200	0–1,200	0–1,200	--
*Solomons Pied Monarch *Symposiachrus barbatus*	21	625–1,293	0–900	0–760	250–1,000	0–1,100	0–1,100	0–1,200	0–1,200	--

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Species	*n*	this study	Hamlin (1928)	Diamond (1975)	Schodde (1977)	Hadden (1981)	Hadden (2004)	Dutson (2011)	Gregory (2017)	Woxvold & Novera (2021)
		0–2,712 m	0–1,675 m	0–1,950 m	0–1,500 m	0–1,600 m	0–2,000 m			0–1,765 m
*Bougainville Monarch *Monarcha erythrostictus*	12	951–1,801	0–>1,675	0–≥850	(300–) 700–1,000	0–1,200	0–1,200	0–1,300	0–1,300	to 1,525
*Steel-blue Flycatcher *Myiagra ferrocyanea*	37	10–1,676	0–1,050	0–850	0–1,500	0–1,500	0–max	0–1,500	0–1,500	--
Bougainville Crow *Corvus meeki*	15	11–1,441	0–>1,675	0–≥1,600	0–800	0–1,600	0–1,600	0–1,600	0–1,600	--
Solomons Robin *Petroica polymorpha	4	1,981–2,437	1,200–>1,675	1,200–≥1,950	--	1,200–1,950	1,200–max	>1,200	1,200–1,950	--
*Pacific Swallow *Hirundo tahitica*	8	6–622	--	--	0–600	--	--	--	--	--
Bougainville Bush Warbler *Horornis haddeni	12	989–1,729	--	1,140–1,340	--	850–1,300	700–1,500	700–1,500	700–1,500	to 1,500
Island Leaf Warbler *Phylloscopus poliocephalus	32	951–2,447	1,200–>1,675	970–≥1,950	--	>900	700–max	>700	>700	--
Australian Reed Warbler *Acrocephalus australis*	2	2–7	--	--	--	--	--	--	0–1,600	--
Bougainville White-eye *Zosterops hamlini	38	951–2,433	750–>1,675	900–≥1,950	>1,200	>900	(750–) 1,000–max	> (750–) 900	>900	--
*Yellow-throated White-eye *Zosterops metcalfii*	141	6–1,357	0–900	0–900	0–700	0–900	0–1,000	0–900 (–1,200)	0–900 (–1,200)	--
Metallic Starling *Aplonis metallica*	4	6–771	--	--	0–250	0–250	--	0–600	0–1,100	--
Singing Starling *Aplonis cantoroides*	12	6–794	--	--	0–300	0–'Panguna'	0–800	0–750	0–1,600	--
Brown-winged Starling *Aplonis grandis*	8	14–867	0–900	0–670	0–450	0–750	0–950	0–750	0–750	--
*Long-tailed Myna *Mino kreffti*	138	6–1,251	0–900	0–600	0–500	0–1,050	0–1,000	0–600 (–1,100)	0–600 (–1,000)	--
Bougainville Thrush *Zoothera atrigena	1	2,106	--	--	--	>1,500	>1,500	>1,500	>1,500	--
Island Thrush *Turdus poliocephalus	1	2,003	1,200–>1,675	--	1,400–1,500	>1,500	1,400–max	>1,200	>1,200	--
*Midget Flowerpecker *Dicaeum aeneum*	62	6–1,981	0–>1,675	0–≥1,300	0–1,500	0–'high mountains'	0–max	0–max	--	--
Sahul Sunbird *Cinnyris frenata*	16	6–635	0–600	0–600	0–270	0–'Panguna'	--	0–800	0–800	--
*Blue-faced Parrotfinch *Erythrura trichroa*	4	1,123–1,981	--	1,130–≥1,950	--	0–1,950	0–1,950	0–max	--	--

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conducted, one in 1964 at Mt. Loloru, South Bougainville (Schodde 1977), and another in 1972 at Mt. Balbi (Diamond 1975). The first expedition established its highest camp at *c.*760 m and sampled the montane avifauna via daily excursions to about 1,500 m (Schodde 1977).

J. Diamond ascended Mt. Balbi from Togarao village on its southern side, reaching *c.*1,950 m. He provided comprehensive elevational distribution data and recorded species substitutions with varying elevation (Diamond 1975). During his expedition, he became the first Western ornithologist to notice the famous song of the Bougainville Bush Warbler *Horornis haddeni*. The species remained an enigma for several years due to its elusive nature and its preference for steep slope habitat (Beehler 1983). It was not until 2006, almost 34 years after the first sighting, that the species was formally described (LeCroy & Barker 2006).

D. Hadden worked on Bougainville during 1976–80 and 1999–2002. On a subsequent visit to Mt. Balbi in May 2002 (Hadden 2004), he reached the same spot as Diamond at *c.*2,000 m. In the Crown Prince Range, he collected no fewer than three bird species new to science (Ripley & Hadden 1982, Hadden 1983, LeCroy & Barker 2006) and wrote the first comprehensive books on the birds of the North Solomons (Hadden 1981, 2004).

The 'Bougainville crisis' interrupted his work. This conflict was triggered mainly by unsettled issues related to the Panguna copper mine and lasted from 1988 until 1998. As a result, Bougainville was inaccessible to naturalists for many years. In 2001, a peace agreement was signed, and a referendum held in 2019 could lead to Bougainville's future independence.

Post-war, accessibility of many areas on Bougainville has improved, but access to some areas, particularly in the Panguna region, is still restricted or impossible due to unresolved issues. The only study conducted since was in 2019 in the Aiope River catchment area, Kunua District, on the north-west coast of Bougainville (Woxvold & Novera 2021). The elevational gradient spanned from the coastal plain to almost 1,800 m.

Higher elevations of Mt. Balbi above 2,000 m have remained largely unstudied ornithologically. The only available records are from birdwatchers: K. Pohlman in 2010, P. Gregory in 2011 and A. Banwell in 2017 (www.ebird.org). In addition, some sound-recordings made by T. Mark in 2014 have been archived at Xeno-canto (www.xeno-canto.org; XC).

Fifty years after Diamond's study of Mt. Balbi's avifauna in August 1972, his elevational sequence was resurveyed in November 2022 over four consecutive days. I extended his transect to the summit and covered elevations from 850 to 2,712 m. With the aim of collecting data on potential changes in elevational ranges over the past five decades, special attention was paid to the lower and upper limits of species occurrence. Data on elevational distribution and species abundance were also obtained via counts along a series of line transects on Mt. Balbi and elsewhere on Bougainville and Buka Islands to provide rough estimates of species abundance.

Material and Methods

Field work was conducted on 2–17 November 2022. Elevational transects were surveyed on Mt. Balbi (via the same route as Diamond 1972 and Hadden in 2002) and the Keriaka limestone karst, both in the Rotokas region of central Bougainville. Additional records were made between Togarao and Puriri villages, also in central Bougainville, and Boruoma Hill (*c.*1,070 m) in the Crown Prince Range above Panguna. Lowland birds were counted along transects in southern Buka and on the west coast of Bougainville in Atsinima and Torokina regions (Table 2). A list of villages and other localities mentioned in the text and their coordinates are given in Appendix 1.

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TABLE 2
List of transects.

Name	Habitat	Date	Elevation (min–max, m)	Distance (km)
S Buka	mixed lowland forest and plantations	2 Nov 2022	15–51	9.8
Mt. Balbi <1,300 m	lower montane forest	4, 5 and 7 Nov 2022	837–1,300	3.1
Mt. Balbi >1,300 m	upper montane and elfin forest	5–7 Nov 2022	1,300–2,463	6.1
Togarao–Puriri	mixed hill forest and farmland	4, 7–9 Nov 2022	524–1,044	17.2
Keriaka	('bamboo degraded') hill and montane forest	9–10 Nov 2022	731–1,328	11.3
Asitaipa–Tutupei	mixed hill forest and farmland	11 Nov 2022	100–731	5.0
Tutupei–Poritai	mixed lowland forest and farmland	11 Nov 2022	10–100	13.5
Torokina–Piva	mixed lowland forest and farmland	13 Nov 2022	0–41	9.3
Boruoma Hill	lower montane forest	15 Nov 2022	845–1,033	4.2
Buka town	urban	17 Nov 2022	2–15	6.4

TABLE 3
Sites of overnight autonomous sound-recording.

Name	Latitude	Longitude	Elevation (m)	Date
Mt. Balbi, Camp 0	-5.93982	155.03896	1,293	4–5 Nov 2022
Mt. Balbi, Camp 3	-5.92834	154.99730	2,433	5–6 Nov 2022
Mt. Balbi, Camp 1	-5.93224	155.02116	1,981	6–7 Nov 2022
Keriaka Camp	-6.02505	154.98890	1,251	9–10 Nov 2022
Torokina airfield	-6.20280	155.06579	41	12–13 Nov 2022

To obtain coordinates and precise elevations for each record, I tracked my route via GPS using a Samsung Galaxy S10 smartphone and the Ultra GPS Mapper app. Bird records were linked to GPS coordinates by their time stamp and plotted on a map in QGIS (QGIS.org 2023). SRTM data (NOAA 1999) were used to determine precise elevations.

Identification of bird species was based primarily on their vocalisations, although many species were also observed using binoculars. Xeno-canto sound files were used in the field to help assign vocalisations to species. Additional and invaluable help was provided by local guides, especially on Mt. Balbi. Furthermore, sound-recordings of several species were made using a Sennheiser ME 66 directional microphone and an Olympus LS-P1 recorder. Nocturnal recordings were made using an autonomous recording unit, a Wildlife Acoustics Song Meter Micro, at about 1,290 m, 1,980 m and 2,430 m on Mt. Balbi, at 1,250 m at Keriaka and at 40 m at Torokina airfield (Table 3). The recorder was also deployed while walking in the morning, when many birds were vocally active (Diamond *et al*. 2019) and additional species to those detected in the field at the time were identified subsequently on these recordings. The automated sound-recordings comprise 144 hours and were analysed using Kaleidoscope software. Sixty-two sound files of 32 species have been uploaded to Xeno-canto (https://xeno-canto.org/set/8657) and my bird records are available at eBird (www.ebird.org). Sonograms were made using R, version 4.3.2 (R Core Team 2023) and the packages 'seewave' (Sueur *et al*. 2008) and 'tuneR' (Ligges *et al*. 2023).

While hiking up and down Mt. Balbi, at some sites potentially the same individuals were recorded twice, with in some cases a third record made by the automated sound-recorder. Such clusters were identified via the GIS map and interpreted as a single individual/territory to estimate population density (Bowen 1997).

Vegetation on Mt. Balbi is largely undisturbed, with human influence noticeable only at lower elevations. Gardens of the Togarao people end at *c*.850 m and montane forest dominates thereafter. Above 1,300 m, no human impacts are visible and the forest appears

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pristine. In contrast, in the north-western part of the Keriaka limestone karst, along the path between Puriri and Asitaipa, only patches of the original montane forest remained. Large areas are being degraded by bamboo, which spreads rapidly by overgrowing open areas after an old tree has died, colonising regrowth and thus degrading forest quality. Villagers' gardens in Asitaipa ended at *c.*750 m, and in Puriri at *c.*1,000 m. In the Crown Prince Range, uncontrolled mining has spread around Panguna in recent years. Satellite imagery reveals that the mined area extends along the upper Kupei Road up to the pass towards Arawa, an area previously known to be rich in birdlife (Hamlin 1928, Hadden 1981, 2004) but now appears devastated.

Results

Some 1,428 records were made of 79 species, of which 68 were breeding landbirds, comprising 1,404 individual records obtained visually, acoustically or by automated sound-recording (see Table 1 for elevational distributions compared to data from previous work). Twenty-eight breeding landbird species that occur on Bougainville were not recorded.

Compared to Diamond's initial survey of Mt. Balbi, 29 of the 37 species for which elevational ranges were reported were found at higher elevations than 50 years ago (Fig. 2), most of them regularly. Six were species found by Diamond at his max. elevation

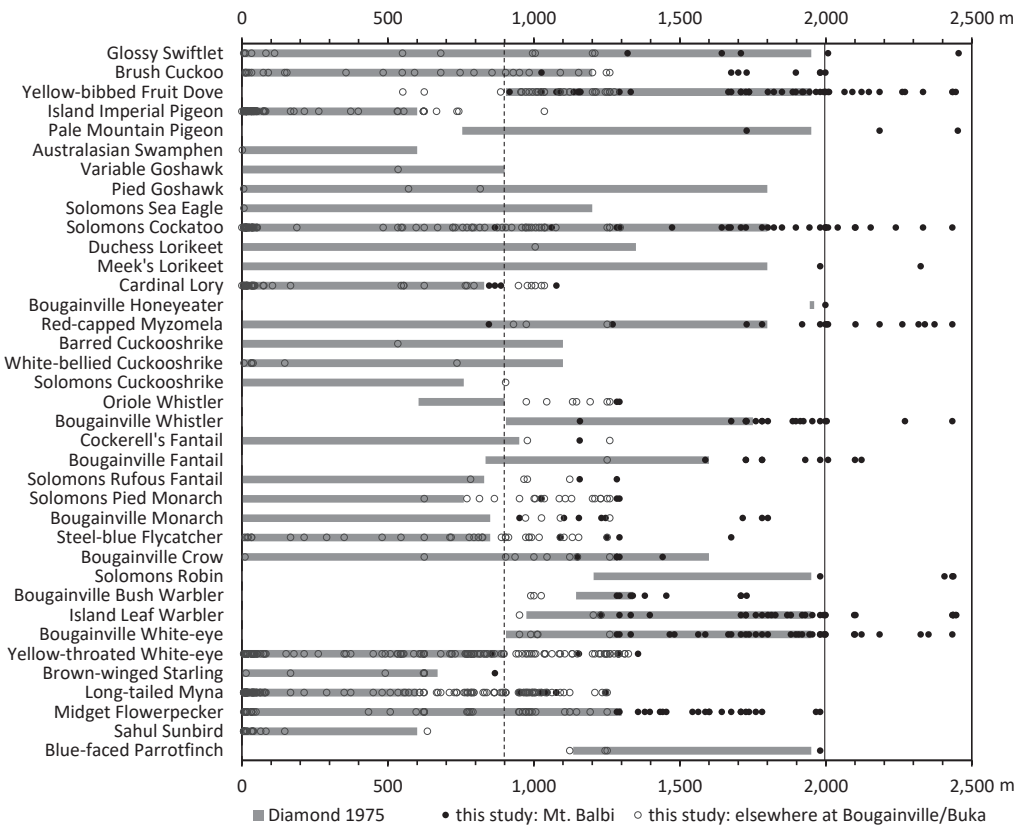

Figure 2. Elevational ranges of 37 species on Mt. Balbi from Diamond (1975) compared to the results of the present study at Mt. Balbi and other sites on Bougainville and Buka (during this study, transects on Mt. Balbi ran from *c.*850 m to the summit at 2,712 m; continuous line = max. elevation reached by Diamond 1972 and (probably) Hadden 2002; dashed line = elevation from which it rained almost uninterruptedly during Diamond's visit).

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of 1,950 m, but were not confined to it, and were now recorded up to the treeline: Glossy Swiftlet *Collocalia esculenta*, Yellow-bibbed Fruit Dove *Ptilinopus solomonensis*, Pale Mountain Pigeon *Gymnophaps solomonensis*, Solomons Robin *Petroica polymorpha*, Island Leaf Warbler *Phylloscopus poliocephalus* and Bougainville White-eye *Zosterops hamlini*. In total, ten species were found close to the treeline on Mt. Balbi at *c*.2,450 m, indicating that there is no upper range limit for these birds, at least on Bougainville. In addition to the six species just mentioned, these were Solomons Cockatoo *Cacatua ducorpsii*, Meek's Lorikeet *Vini meeki*, Red-capped Myzomela *Myzomela lafargei* and Bougainville Whistler *Pachycephala richardsi*. No birds were recorded above the treeline.

Another group of 15 species included those which, according to Diamond, are restricted to elevations below the max. elevation reached by him. Some of these were found much higher than 50 years ago, e.g. Bougainville Monarch *Monarcha erythrostictus c*.950 m, Brush Cuckoo *Cacomantis variolosus* and Steel-blue Flycatcher *Myiagra ferrocyanea c*.800 m, and Solomons Pied Monarch *Symposiachrus barbatus c*.500 m higher. Even very common and conspicuous species fall into this category, e.g. Yellow-throated White-eye *Zosterops metcalfii* and Long-tailed Myna *Mino kreffti*, which were frequently found above the max. elevation reported by Diamond (1975) (Fig. 2). In total, new elevation records were obtained for 35 species (Table 1).

Other than a small number of species for which insufficient observations were available to make an assessment, just four species were restricted to more or less the same elevation as during Diamond's visit: Bougainville Honeyeater *Stresemannia bougainvillei*, Bougainville Crow *Corvus meeki*, Sahul Sunbird *Cinnyris frenata* and Blue-faced Parrotfinch *Erythrura trichroa* (Fig. 2).

In addition to records of elevational distribution, density estimates are provided for regularly encountered conspicuous species, i.e. birds easily detected in the field by their behaviour (e.g. Bougainville Crow *Corvus meeki*, Solomons Cockatoo or Coconut Lorikeet *Trichoglossus haematodus*) or their vocalisations (mostly songbirds, but also pigeons and cuckoos) (Table 4).

Species accounts

Given the general information already reported by Woxvold & Novera (2021), the accounts focus on new elevational distribution data, as well as nesting and abundance information. Species with new max. elevation records are marked *. New lower elevation records are denoted °. Nesting records are indicated +.

*__GLOSSY SWIFTLET__ *Collocalia esculenta lagonoleucos*
Described previously as occurring up to the highest mountaintops (Hadden 2004, Dutson 2011, Gregory 2017). This was confirmed by a sighting at 2,455 m on Mt. Balbi.

*__BRUSH CUCKOO__ *Cacomantis variolosus addendus*
Regularly heard. Common and widespread in the lowlands and recorded on Mt. Balbi up to 2,000 m, more than 800 m higher than 50 years ago (Diamond 1975).

*__MACKINLAY'S CUCKOO-DOVE__ *Macropygia mackinlayi arossi*
Widespread and common in montane habitats, but recorded only twice below 950 m in my study, at 167 m near Tutupei (Atsinima region) and at 737 m near Togarao village. On Mt. Balbi very abundant at 1,300–2,000 m with *c*.20 singing males per 2.5 km. The highest elevation was 2,100 m, extending the species' known range *c*.500 m upslope (Hamlin 1928,

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TABLE 4
Number and density of selected (conspicuous) species along transects (units: singing males, territories or pairs for territorial species; individuals for non-territorial species [*]; x = species present; transect details in Table 2).

Species	No. of transects with species	S Buka		Mt. Balbi <1,300 m		Mt. Balbi >1,300 m		Togarao–Puriri		Keriaka		Asitaipa–Tutupei		Tutupei–Poritai		Torokina–Piva		Boruoma Hill		Buka town	
		n	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km
Glossy Swiftlet *Collocalia esculenta* *	8	2	0.2	0	0	>5	>0.8	2	0.1	2	0.2	>5	>1	>13	>1	>10	>1.1	>3	>0.7	0	0
Pacific Koel *Eudynamys orientalis*	4	1	0.1	0	0	0	0	1	0.1	0	0	0	0	3	0.2	1	0.1	0	0	0	0
Brush Cuckoo *Cacomantis variolosus*	8	0	0	1	0.3	4	0.7	5	0.3	4	0.4	2	0.4	5	0.4	2	0.2	3	0.7	0	0
MacKinlay's Cuckoo-Dove *Macropygia mackinlayi*	6	0	0	3	1.0	*c*.27	*c*.4.4	3	0.2	7	0.6	1	0.2	0	0	0	0	1	0.2	0	0
Crested Cuckoo-Dove *Reinwardtoena crassirostris*	5	0	0	1	0.3	1	0.2	1	0.1	7	0.6	0	0	0	0	0	0	2	0.5	0	0
Superb Fruit Dove *Ptilinopus superbus*	4	0	0	4	1.3	0	0	3	0.2	4	0.4	0	0	1	0.1	0	0	0	0	0	0
Yellow-bibbed Fruit Dove *Ptilinopus solomonensis*	6	0	0	11	3.5	24	3.9	1	0.1	17	1.5	3	0.6	0	0	0	0	4	0.9	0	0
Claret-breasted Fruit Dove *Ptilinopus viridis*	7	0	0	1	0.3	0	0	7	0.4	10	0.9	4	0.8	5	0.4	3	0.3	4	0.9	0	0
Red-knobbed Imperial Pigeon *Ducula rubricera*	9	4	0.4	7	2.3	0	0	23	1.3	17	1.5	8	1.6	15	1.1	11	1.2	1	0.2	2	0.3
Island Imperial Pigeon *Ducula pistrinaria*	7	x	-	0	0	0	0	*c*.10	*c*.0.6	3	0.3	5	1.0	*c*.50	*c*.3.7	26	2.8	0	0	12	1.9
Papuan Hornbill *Rhyticeros plicatus* *	10	5	0.5	7	2.3	2	0.3	2	0.1	6	0.5	5	1.0	4	0.3	5	0.5	1	0.2	2	0.3
Oriental Dollarbird *Eurystomus orientalis*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.2	0	0	0	0
Ultramarine Kingfisher *Todiramphus leucopygius*	4	0	0	0	0	0	0	1	0.1	0	0	2	0.4	1	0.1	3	0.3	0	0	0	0
Melanesian Kingfisher *Todiramphus tristrami*	7	1	0.1	0	0	1	0.2	4	0.2	2	0.2	6	1.2	7	0.5	4	0.4	0	0	0	0
Solomons Cockatoo *Cacatua ducorpsii* *	8	10	1.0	4	1.3	*c*.20	*c*.3.3	*c*.30	*c*.1.7	*c*.15	*c*.1.3	2	0.4	*c*.25	*c*.1.9	*c*.15	*c*.1.6	0	0	0	0
Papuan Eclectus *Eclectus polychloros*	5	1	0.1	0	0	0	0	3	0.2	2	0.2	0	0	2	0.1	2	0.2	0	0	0	0
Cardinal Lory *Pseudeos cardinalis* *	8	*c*.100	*c*.10.3	17	5.5	0	0	*c*.15	*c*.0.9	6	0.5	5	1.0	*c*.20	*c*.1.5	*c*.30	*c*.3.2	0	0	3	0.5
Coconut Lorikeet *Trichoglossus haematodus*	9	2	0.2	3	1.0	*c*.3	*c*.0.5	9	0.5	*c*.10	*c*.0.9	4	0.8	3	0.2	4	0.4	1	0.2	0	0
Red-capped Myzomela *Myzomela lafargei* *	4	0	0	2	0.6	*c*.23	*c*.3.8	0	0	1	0.1	0	0	0	0	0	0	4	0.9	0	0
White-bellied Cuckooshrike *Coracina papuensis*	3	0	0	0	0	0	0	1	0.1	0	0	0	0	2	0.1	1	0.1	0	0	0	0
Grey-capped Cicadabird *Edolisoma remotum*	3	0	0	0	0	0	0	3	0.2	1	0.1	1	0.2	0	0	0	0	0	0	0	0

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Species	No. of transects with species	S Buka		Mt. Balbi <1,300 m		Mt. Balbi >1,300 m		Togarao–Puriri		Keriaka		Asitaipa–Tutupei		Tutupei–Poritai		Torokina–Piva		Boruoma Hill		Buka town	
		n	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km	*n*	n/km
Oriole Whistler *Pachycephala orioloides*	3	0	0	1	0.3	0	0	0	0	6	0.5	0	0	0	0	0	0	1	0.2	0	0
Bougainville Whistler *Pachycephala richardsi*	2	0	0	1	0.3	14	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willie Wagtail *Rhipidura leucophrys*	3	2	0.2	0	0	0	0	0	0	0	0	0	0	0	0	6	0.6	0	0	18	2.8
Cockerell's Fantail *Rhipidura cockerelli*	3	0	0	1	0.3	0	0	1	0.1	1	0.1	0	0	0	0	0	0	0	0	0	0
Bougainville Fantail *Rhipidura drownei*	2	0	0	0	0	8	1.3	0	0	1	0.1	0	0	0	0	0	0	0	0	0	0
Solomons Rufous Fantail *Rhipidura rufofronta*	4	0	0	2	0.6	0	0	2	0.1	1	0.1	0	0	0	0	0	0	1	0.2	0	0
Solomons Pied Monarch *Symposiachrus barbatus*	5	0	0	1	0.3	0	0	4	0.2	10	0.9	1	0.2	0	0	0	0	0	0	0	0
Bougainville Monarch *Monarcha erythrostictus*	4	0	0	4	1.3	2	0.3	1	0.1	3	0.3	0	0	0	0	0	0	0	0	0	0
Steel-blue Flycatcher *Myiagra ferrocyanea*	9	1	0.1	3	1.0	1	0.2	11	0.6	6	0.5	6	1.2	3	0.2	2	0.2	3	0.7	0	0
Bougainville Crow *Corvus meeki*	5	4	0.4	2	0.6	0	0	0	0	4	0.4	1	0.2	0	0	0	0	3	0.7	0	0
Solomons Robin *Petroica polymorpha*	1	0	0	0	0	4	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bougainville Bush Warbler *Horornis haddeni*	3	0	0	1	0.3	5	0.8	0	0	0	0	0	0	0	0	0	0	3	0.7	0	0
Island Leaf Warbler *Phylloscopus poliocephalus*	4	0	0	2	0.6	*c.*23	*c.*3.8	0	0	2	0.2	0	0	0	0	0	0	1	0.2	0	0
Bougainville White-eye *Zosterops hamlini* *	4	0	0	1	0.3	*c.*100	*c.*16.4	0	0	*c.*5	*c.*0.4	0	0	0	0	0	0	8	1.9	0	0
Yellow-throated White-eye *Zosterops metcalfii* *	10	16	1.6	3	1.0	1	0.2	*c.*50	*c.*2.9	54	4.8	*c.*20	*c.*4	28	2.1	*c.*20	*c.*2.2	13	3.1	1	0.2
Long-tailed Myna *Mino kreffti* *	9	27	2.8	7	2.3	0	0	38	2.2	18	1.6	12	2.4	43	3.2	9	1.0	8	1.9	2	0.3
Midget Flowerpecker *Dicaeum aeneum*	8	0	0	1	0.3	*c.*20	*c.*3.3	11	0.6	5	0.4	4	0.8	7	0.5	2	0.2	5	1.2	0	0
Sahul Sunbird *Cinnyris frenata*	5	x	-	0	0	0	0	1	0.1	0	0	0	0	*c.*5	*c.*0.4	*c.*10	*c.*1.1	0	0	1	0.2

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Dutson 2011). At Keriaka, it was much rarer, perhaps due to the widespread prevalence of bamboo along the trail. Seven singing males were recorded along the 11.3 km transect.

*__CRESTED CUCKOO-DOVE__ *Reinwardtoena crassirostris*
Rarer than the previous species on Mt. Balbi, where just two territorial males were recorded, but equally abundant at Keriaka, with seven singing males in 11.3 km. Recorded at *c.*2,000 m on Mt. Balbi, well above the previously reported max. of 1,100 m (Gregory 2017) or 1,500 m (Dutson 2011).

__SUPERB FRUIT DOVE__ *Ptilinopus superbus superbus*
Although mostly noted to be restricted to elevations below 800 m (Hadden 1981, 2004, Gregory 2017), this species was found up to 1,250 m, in accord with Dutson (2011).

*°+__YELLOW-BIBBED FRUIT DOVE__ *Ptilinopus solomonensis bistictus*
This montane species replaces Superb *P. superbus* and Claret-breasted Fruit Doves *P. viridis*, which are mostly restricted to lower elevations (Diamond 1975). It was abundant above 900 m, especially on Mt. Balbi, where 35 singing males were recorded up to the treeline at *c.*2,450 m along a transect of *c.*8.6 km. Lower densities were recorded at Keriaka, with 17 territorial males along a 10.3 km transect. Just three were recorded below 900 m, in and below Asitaipa village on the southern escarpment of the Keriaka karst at 625 and 550 m respectively. The latter is lower than the previously reported lowest elevation of 600 m (Dutson 2011, Gregory 2017).

A nest was found on 5 November (and visited again the next day) at *c.*2,010 m near Camp 1 (known among the Rotokas as Auskeapi) on the southern slope of Mt. Balbi. The site was covered by dense upper montane cloud forest and the nest was on a nearly horizontal branch of a giant understorey fern, *c.*1.5 m above ground. It was a fragile structure of twigs and contained a single creamy-white egg (Fig. 3), as also described by

Figure 3. Nest of Yellow-bibbed Fruit Dove *Ptilinopus solomonensis* with a single egg, *c.*2,010 m, Mt. Balbi, Bougainville (Jan-Uwe Schmidt)

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Figure 4. Male Yellow-bibbed Fruit Dove *Ptilinopus solomonensis* at the nest shown in Fig. 3, *c*.2,010 m, Mt. Balbi, Bougainville (Jan-Uwe Schmidt)

Schodde (1977) and Hadden (2004). The incubating bird was photographed and was a male (Fig. 4), so apparently both sexes share this role (see Meyer 1930). As nests have been found on Bougainville in April (Hadden 2004), August (Schodde 1977) and now November, the species probably breeds year-round, as also reported on Vuatom Island in the Bismarck Archipelago (Meyer 1930).

***CLARET-BREASTED FRUIT DOVE** *Ptilinopus viridis lewisii*
Widespread in the lowlands and hill country. I found it on Mt. Balbi up to *c*.1,150 m and on the Keriaka limestone karst up to 1,260 m, extending its known range upslope by *c*.300 m (Hamlin 1928, Dutson 2011).

***RED-KNOBBED IMPERIAL PIGEON** *Ducula rubricera rufigula*
Widespread on Bougainville and, although previously sometimes described as being confined to the lowlands (Schodde 1977, Hadden 1981), it has been found in lower montane forest to *c*.800–900 m (Hamlin 1928, Hadden 2004, Woxvold & Novera 2021), as well as at 1,200 m on Kolombangara (Weeks *et al*. 2017) and 1,100 m on New Ireland (T. Mark; XC170169); Dutson (2011) reported its upper limit as 1,250 m. It was therefore unsurprising to find the species common up to 1,150 m on Mt. Balbi (five records above 950 m) and to 1,260 m on the Keriaka limestone karst (nine records above 1,000 m) in November 2022. At Boruoma Hill above Panguna, one was heard at 1,000 m.

***†ISLAND IMPERIAL PIGEON** *Ducula pistrinaria pistrinaria*
This small-island specialist occurs surprisingly far inland on Bougainville (Diamond 1975: *c*.16 km). A small colony was found at Togarao village in the centre of the island, 17 km from the coast at 620 m. It occurs up to at least 750 m on Mt. Balbi and was recorded at 1,036 m on the Keriaka limestone karst plateau. Whereas the record on Mt. Balbi was at the edge of the cultivated area above Togarao, at Keriaka the species was found in a more undisturbed

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environment. In general, however, this *Ducula* is still found mainly on the coastal plains, where it occurs at high densities, e.g. *c*.50 individuals per 13.5 km between Tutupei and Poritai, and 26 over 9.3 km between Torokina and Piva. A nest was found at Piva on 12 November. It was a fragile construction of a few sticks, on a long branch overhanging the road close to a spot where cars regularly stop. The number of eggs could not be ascertained as the nest was *c*.6–8 m above ground. Nesting peaks in December and January according to Hadden (2004).

***PALE MOUNTAIN PIGEON** *Gymnophaps solomonensis*
This rather elusive and nomadic Solomons endemic was recorded on Mt. Balbi in upper montane and elfin forest between *c*.1,700 m and the treeline at *c*.2,450 m. Hamlin (1928), Diamond (1975) and Hadden (2004) all found the species on Bougainville at the max. elevations they reached, 1,675 m, 1,950 m and 2,000 m, respectively. The reported max. breeding elevation of 1,565 m (Dutson 2011, Gregory 2017) seems too low.

WEST SOLOMONS OWL *Athene jacquinoti eichhorni*
Regularly found in a wide variety of habitats, both near villages and in pristine montane forest. Hadden noted that it may occur to the treeline, but this requires confirmation as the highest record was at *c*.2,000 m on Mt. Balbi, consistent with Dutson (2011) and Gregory (2017).

FEARFUL OWL *Asio solomonensis*
Only a single call of this species was recorded during five nights of automated sound-recording at apparently suitable sites. The recording was made at 1,250 m in bamboo-degraded forest near Keriaka Camp. This owl is apparently elusive, calls infrequently (like congenerics) and is, therefore, easily overlooked. However, with recent records at 2,000 m on Mt. Balbi (Hadden 2004) and at 1,600 m in the upper Aiope River basin (Woxvold & Novera 2021), it appears to be fairly widespread over a broad elevational range.

***PAPUAN HORNBILL**[1] *Rhyticeros plicatus*
Common in the lowlands and hill country, in agricultural areas and even near Buka town (see Table 4). Described as occurring to *c*.1,500 m (Schodde 1977, Hadden 1981, Dutson 2011, Gregory 2017), but recorded up to 1,675 m by the WSSE (Hamlin 1928). On Mt. Balbi, it was recorded at 1,700 m, the highest elevation for the species on Bougainville.

ULTRAMARINE KINGFISHER *Todiramphus leucopygius*
Less common than the next species, but widespread, even near villages and on agricultural land. It is more confined to the lowlands than its congener and appears to avoid closed forest.

***MELANESIAN KINGFISHER** *Todiramphus tristrami alberti*
Recently split from the geographically very widespread Collared Kingfisher *T. chloris*. Common on Bougainville, even in villages and farmland. On Mt. Balbi, it was recorded at 1,543 m, a new max. elevation, but consistent with Woxvold & Novera (2021) and Dutson (2011), who found the species at 1,420 m on Bougainville and up to 1,500 m on New Britain, respectively, and the distribution of the Collared Kingfisher superspecies up to 1,500 m, e.g., on Java (Woodall 2020).

[1] Blyth's Hornbill *sensu* Gill *et al*. (2024) but Papuan Hornbill seems a more appropriate name (Gregory 2017).

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Figure 5. Solomons Cockatoos *Cacatua ducorpsii*, c.2,100 m, Mt. Balbi, Bougainville (Jan-Uwe Schmidt)

*__SOLOMONS COCKATOO__ *Cacatua ducorpsii*

This noisy bird is very conspicuous and common in both montane forest (Fig. 5) and mixed agricultural lowlands. It usually occurs singly or in small flocks of 2–5. Solomons Cockatoo was found up to the highest elevations, even Mt. Balbi Camp 3 at 2,435 m.

°__RED-BREASTED PYGMY PARROT__ *Micropsitta bruijnii rosea*

A small flock feeding in a tree at 534 m in Uriora village, central Bougainville, was a rather low record for this montane species, which usually occurs above *c*.700 m (Dutson 2011, Gregory 2017). Hadden (2004) saw it only above 1,200 m. However, the species has been occasionally seen at lower elevations, e.g., down to 150 m (Mayr 1978) and has recently been reported from *c*.500 m (D. Biggs, https://ebird.org/checklist/S154886351).

*+__PAPUAN ECLECTUS__ *Eclectus polychloros solomonensis*

This large parrot is widespread and apparently not rare, although it is occasionally kept as a pet by villagers, e.g., in Uriora (central Bougainville) and Nova (southern Buka). Birds visiting potential nest holes were seen in southern Buka and on the Keriaka plateau. A record at 1,251 m on the Keriaka plateau is the highest known record on Bougainville.

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*SONG PARROT *Geoffroyus heteroclitus heteroclitus*
Although recorded only once during this study, my observation at *c*.1,000 m is a new max. elevation for this species on Bougainville, well above the usually reported upper range limit of 600 m (Hamlin 1928, Schodde 1977, Hadden 1981, 2004).

*MEEK'S LORIKEET *Vini meeki*
A small flock seen at 2,325 m on Mt. Balbi was the highest known record of the species, suggesting that it may occur up to the treeline.

CARDINAL LORY *Pseudeos cardinalis*
Most abundant in the lowlands, where it occurs at high densities, e.g. *c*.10 individuals/km on the southern Buka transect. On Mt. Balbi, it was recorded to 1,077 m, *c*.250 m higher than by Diamond (1975) but consistent with Hadden (2004; to 2,000 m) and Dutson (2011; to 1,200 m).

COCONUT LORIKEET *Trichoglossus haematodus massena*
Occurring in pairs or small flocks, Coconut Lorikeet was often recorded due to its noisy agitated behaviour, probably due to the presence of nests nearby. It was widespread across varied habitat types from the coast to >1,900 m, which is consistent with previous information (Hadden 2004, Dutson 2011, Gregory 2017).

*BOUGAINVILLE HONEYEATER *Stresemannia bougainvillei*
This enigmatic species was recorded just once on Mt. Balbi, at Camp 1 (2,000 m), a known site for the species (Diamond 1975). Several tall trees with red flowers attracted many Red-capped Myzomelas *Myzomela lafargei* and a single Bougainville Honeyeater. T. Mark made a sound-recording at the same site in 2014 (XC184184).

*RED-CAPPED MYZOMELA *Myzomela lafargei*
Endemic to the Solomons and widespread on Bougainville; although not strictly montane, it is much commoner at higher elevations. It was recorded to 2,433 m on Mt. Balbi, the highest elevation recorded for the species and extending its range upslope by *c*.400–600 m (Diamond 1975, Hadden 2004, Dutson 2011, Gregory 2017).

+WHITE-BELLIED CUCKOOSHRIKE *Coracina papuensis perpallida*
The commonest cuckooshrike, regularly found in villages, farmland and secondary forest. A pair carrying nesting material was seen on 11 November 2022 near Tutupei, Atsinima region, indicating breeding at this time. Previously, Hadden (2004) reported nesting on Bougainville in May–June and September–October. In Australia, breeding records are from all months except July, and in southern New Guinea breeding has been recorded in January, March–June, August, October and December (Taylor 2020).

ORIOLE WHISTLER *Pachycephala orioloides bougainvillei*
Part of the Golden Whistler *P. pectoralis* superspecies, this species occurs primarily in hill country and lower montane forest. It was found between 974 and 1,293 m, well above the 600–900 m range given by Diamond (1975). Only one of the nine observations was below 1,000 m, but Woxvold & Novera (2021) found it recently at *c*.730 m.

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***BOUGAINVILLE WHISTLER** *Pachycephala richardsi*
This Bougainville endemic replaces Oriole Whistler *P. orioloides* at higher elevations. Almost 100 years ago, it was 'the most abundant species' at *c.*1,050–1,675 m in the Crown Prince Range (Hamlin 1928). The WSSE found a range overlap with its congener at *c.*900 m. During my study, it was very abundant on Mt. Balbi, especially at 1,675–2,000 m. Twelve of 15 territorial males were in this elevational band over a linear distance of 1.4 km. Two were found >2,000 m, as the species was present even in high-elevation elfin forest at 2,433 m near the treeline, while it was recorded only once below 1,675 m, at 1,158 m. *P. richardsi* was not recorded on the Keriaka plateau where *P. orioloides* was present up to 1,260 m.

***COCKERELL'S (WHITE-WINGED) FANTAIL** *Rhipidura cockerelli septentrionalis*
Widespread but apparently rather rare, with just three records, at Mt. Balbi (1,157 m), Keriaka (1,260 m) and near Puriri (978 m) in central Bougainville. All three records are higher than the max. elevation limit given by Diamond (1975; 950 m). The Keriaka record at 1,260 m is the highest reported for the species on Bougainville, reinforcing that by Woxvold & Novera (2021) at *c.*1,200 m. The species' apparent rarity was also noted by Hadden (2004), who hypothesised that it is probably common but easily overlooked, due to its preference for the forest interior. On the other hand, the distinctive song is almost unmistakable, thus the species is possibly less common than previously thought and future work should focus on obtaining density estimates.

***BOUGAINVILLE FANTAIL** *Rhipidura drownei*
On Mt. Balbi, common within a relatively narrow elevation band between about 1,580 and 2,120 m (eight singing males/2.7 km). It was absent in elfin forest, which may be unsuitable. At Keriaka, it was recorded once at 1,250 m, the only record below 1,580 m. Woxvold & Novera (2021) found the species at *c.*1,500 m, but not at their lower site at *c.*730 m.

***SOLOMONS RUFOUS FANTAIL** *Rhipidura rufofronta commoda*
Observed twice on Mt. Balbi, at 1,157 and 1,284 m, both well above the highest elevation of 830 m recorded by Diamond (1975). My record is the highest known elevation on Bougainville and extends its known range by *c.*100 m (Hadden 2004, Dutson 2011, Gregory 2017).

***SOLOMONS PIED MONARCH** *Symposiachrus barbatus barbatus*
Observed only in remote areas, on Mt. Balbi, up to 1,293 m, slightly above the previously known upper range limit of *c.*1,100–1,200 m (Hadden 2004, Dutson 2011, Gregory 2017).

***BOUGAINVILLE MONARCH** *Monarcha erythrostictus*
Present in the lower montane strata of Mt. Balbi, mainly at *c.*950–1,250 m, but up to *c.*1,800 m, extending the known elevation range upwards by *c.*100 m (Hamlin 1928). Previously reported data on the upper limit are usually too low (Diamond 1975; ≥850 m, Schodde 1977; 1,000 m, Hadden 1981, 2004; 1,200 m, Dutson 2011 and Gregory 2017; 1,300 m), as the WSSE recorded the species to at least 1,675 m, the highest point reached (Hamlin 1928).

***STEEL-BLUE FLYCATCHER** *Myiagra ferrocyanea cinerea*
Widespread and fairly common from the plains to lower montane elevations. Found in both villages and forests. On Mt. Balbi, it was recorded at 1,676 m, exceeding the max. of 1,500 m usually given (Schodde 1977, Hadden 1981, Dutson 2011, Gregory 2017) and almost doubling the upper limit of 850 m found by Diamond (1975). Hadden's (2004: 205)

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statement that the species occurs 'up to the highest mountains' cannot be confirmed, as it was confined to elevations well below the treeline.

BOUGAINVILLE CROW *Corvus meeki*
This vocally very obvious bird is easily encountered by its loud, distinctive alarm calls and habit of circling above people passing through its territory. This behaviour was reportedly used during the crisis years to detect potential enemies in the bush (Hadden 2004; J. Repiriri pers. comm.). However, the species was widely shot because of this. On Bougainville, it was found only in relatively remote mountainous areas, at Mt. Balbi (n = 2[2]), Keriaka (n = 4) and Boruoma Hill above Panguna (n = 3). Along a 10 km lowland transect in southern Buka, where there is no history of fighting, four territorial individuals were heard calling at different locations and the species appears to be present in good numbers.

*SOLOMONS ROBIN** *Petroica polymorpha septentrionalis*
Recorded on Mt. Balbi from 1,981 m to 2,437 m close to the treeline, extending the usually reported upper limit of 1,950 m by *c*.500 m (Diamond 1975, Hadden 1981, Gregory 2017).

*+PACIFIC SWALLOW** *Hirundo tahitica subfusca*
A small colony containing active nests was observed in Togarao village at *c*.620 m on 4–5 and 7–8 November 2022. Hadden (2004) reported breeding on Bougainville in March and September. Only Schodde (1977) gave an upper limit on Bougainville, of *c*.600 m, which my observations basically confirmed.

*BOUGAINVILLE BUSH WARBLER** *Horornis haddeni*
Six singing males were heard on Mt. Balbi at the place described by Diamond (1975), an incredibly steep ravine many tens of metres deep beside the trail, where the species is still common. On Mt. Balbi, it was found between 1,284 and 1,729 m, extending the known range *c*.200 m upslope (Hadden 2004, Dutson 2011, Gregory 2017, Woxvold & Novera 2021). It was not recorded at Keriaka, although steep slopes are a common feature of the rugged limestone karst. At Boruoma Hill above Panguna, three males were singing around 1,000 m. This steep slope specialist (Diamond 1975, Beehler 1983, Hadden 2004) is still widespread and its difficult-to-access habitat appears relatively secure. However, the species' narrow ecological niche makes it vulnerable, e.g., if uncontrolled mining continues to spread around Panguna.

*ISLAND LEAF WARBLER** *Phylloscopus poliocephalus bougainvillei*
This tiny songbird is a true montane species on Bougainville, found primarily above 1,200 m. Only one of 32 records was at lower elevations, at 950 m on Boruoma Hill near Panguna. It was very common (*c*.25 singing males/6.55 km) on Mt. Balbi up to the treeline at *c*.2,450 m.

*BOUGAINVILLE WHITE-EYE** *Zosterops hamlini*
Restricted to the mountains, where it replaces the more widespread Yellow-throated White-eye *Z. metcalfii*. Very common on Mt. Balbi between 1,285 and 2,435 m and the most abundant species there. Many noisy flocks of 5–15 individuals were foraging in the canopy. Both species of white-eye were found in a small zone of overlap at 1,250–1,350 m on Mt. Balbi, *c*.350–450 m higher than 50 years ago (Diamond 1975). At Keriaka, *Z. hamlini* was found only at 1,260 m, the highest elevation visited, but at Boruoma Hill it was present as

[2] Numbers refer to territorial pairs/birds.

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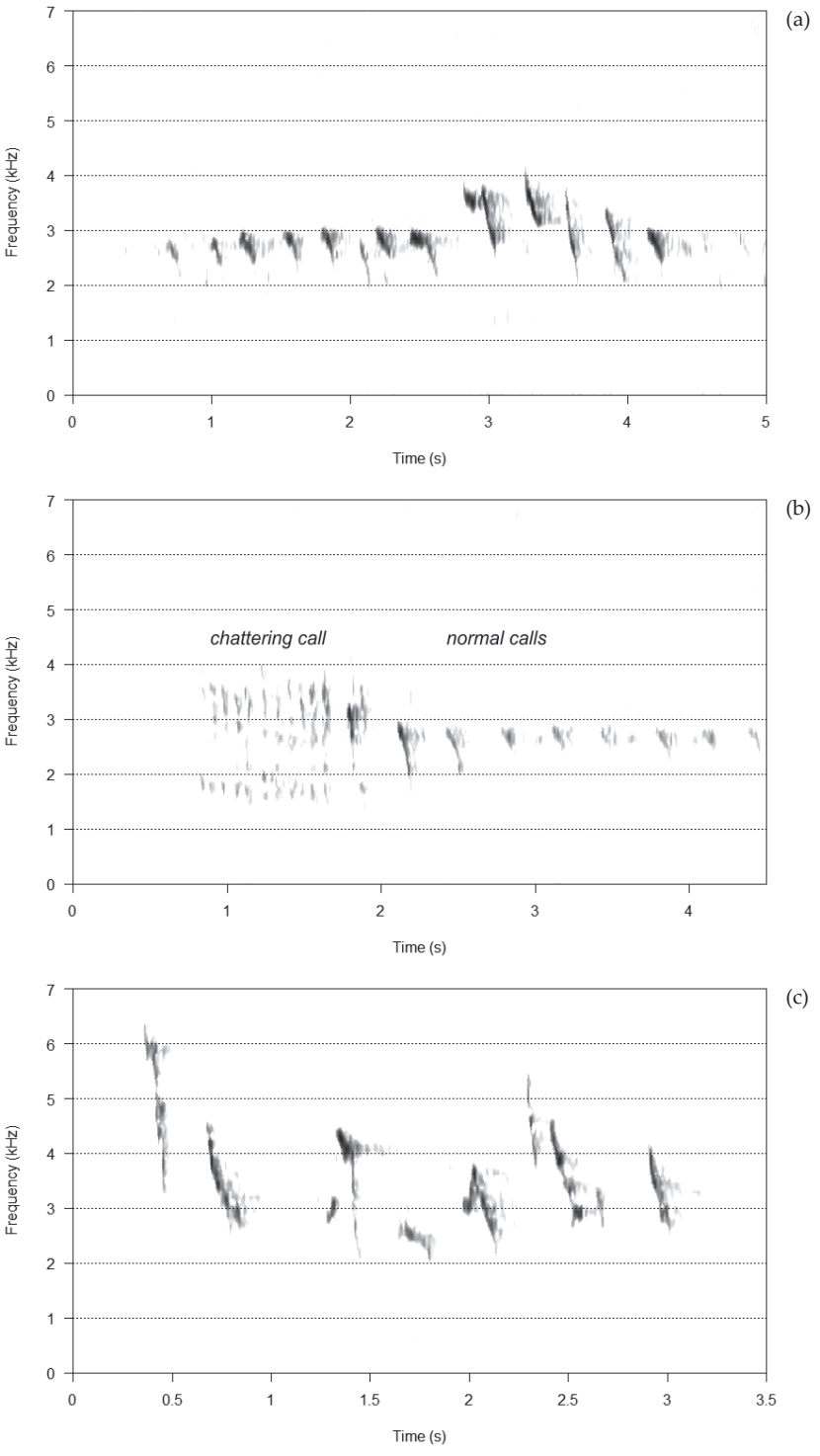

Figure 6. Sonograms of (a) the song (XC828353) and (b) calls of Bougainville White-eye *Zosterops hamlini* (XC828356) recorded on Mt. Balbi, and for comparison (c) the song of Yellow-throated White-eye *Z. metcalfii exiguus* (XC828113) recorded on Buka.

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low as 950 m. The species' song was recorded on Mt. Balbi (Fig. 6a; XC828353, XC828351) and is superficially similar to that of *Z. metcalfii*, but is longer, softer and more monotonous. Calls are softer and deeper than those of *Z. metcalfii*, with a distinct downward turn at the end, giving them a comma signature in sonograms (Fig. 6b). In addition to the usual mellow contact calls, a previously undescribed chatter call was recorded (Fig. 6b; XC828356). Bougainville White-eye was recorded singing during the dawn chorus and regularly, about once per hour, at night.

***YELLOW-THROATED WHITE-EYE** *Zosterops metcalfii exiguus*

The commonest bird species on Bougainville and Buka and, being very vocal, is easy to record. The highest abundance was recorded on the Keriaka limestone karst, where >50 individuals were found along the 11.3 km transect. The upper elevation limit is currently around 1,350 m and the species was very common above 900 m, the upper range limit recorded by many previous studies (Hamlin 1928, Diamond 1975, Hadden 1981).

+BROWN-WINGED STARLING
Aplonis grandis grandis

Three nests in mixed agricultural land around Asitaipa village (*c*.625 m) on the southern escarpment of the Keriaka limestone karst were shown to me by a villager. Birds were seen in close proximity, but did not enter the nests, which were large (*c*.0.5 m in diameter), bulky structures constructed of twigs, grass and leaves (Fig. 7), as described by Hadden (2004). The branches were leafless, making the nests easily visible from a distance.

Figure 7. Nest of Brown-winged Starling *Aplonis grandis*, *c*.600 m, near Asitaipa, Bougainville (Jan-Uwe Schmidt)

***LONG-TAILED MYNA** *Mino kreffti kreffti*

A common and widespread forest starling on Bougainville and Buka. It occurs at sea level in secondary forests and plantations on the outskirts of Buka town, and in natural forests in the hills and lower montane zone. Previously recorded up to about 1,000 m (Hadden 1981, 2004, Dutson 2011, Gregory 2017). Diamond (1975) found that it was restricted to *c*.600 m on Mt. Balbi in 1972. During my study, it was recorded commonly to 1,250 m on both Mt. Balbi and Keriaka: 24 of a total of 138 records were above 1,000 m.

***BOUGAINVILLE THRUSH** *Zoothera atrigena*

Although Gill *et al*. (2024) still list Bougainville Thrush as a subspecies of Black-backed Thrush *Z. talaseae*, which occurs on New Britain and Umboi, it seems better to treat *atrigena* as a species given the plumage differences (e.g. Gregory 2017, del Hoyo *et al*. 2020). The species is confined to the highest mountains of Bougainville, is therefore rarely encountered and has not been recorded outside the Crown Prince Range. The last known record was almost 20 years ago (Hadden 2004). A bird resembling this species was observed on 5 November 2022 at 2,106 m on Mt. Balbi. The bird had a black back, white breast and belly, and was perched in a 45° upright position on a dead tree trunk. Unfortunately, it flew off before I could take a photo, meaning the record should be treated as unconfirmed.

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Figure 8. Island Thrush *Turdus poliocephalus*, *c*.2,000 m, Mt. Balbi, Bougainville (Jan-Uwe Schmidt)

***ISLAND THRUSH** *Turdus poliocephalus bougainvillei*

The Bougainville subspecies of this widespread and very variable bird superficially resembles other all-black thrushes, such as Eurasian Blackbird *T. merula*. Strictly montane and rarely recorded in recent decades. A small feeding party of Red-capped Myzomelas *Myzomela lafargei* and at least two Island Thrushes was recorded at *c*.2,000 m on Mt. Balbi, near Camp 1 (Fig. 8).

***†MIDGET FLOWERPECKER** *Dicaeum aeneum aeneum*

This Solomons endemic is common on Bougainville from the coastal plains to *c*.2,000 m and occurs locally at high densities (e.g. 15–19 territories along 1.5 km between 1,300 and 1,800 m on Mt. Balbi). It was not recorded in elfin forest, although the species is active and vocal, so there may be some elevational limit, *contra* Hadden (2004) and Dutson (2011), who stated that the species occurs to the highest parts of the mountains. A nest containing two white eggs was discovered on 7 November 2022 at 1,380 m on

Figure 9. Nest of Midget Flowerpecker *Dicaeum aeneum* containing two eggs, 1,380 m, Mt. Balbi, Bougainville (Jan-Uwe Schmidt)

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Mt. Balbi. The nest was an oval woven structure with a side entrance, suspended from a low branch *c*.1.8 m above ground (Fig. 9).

Discussion

Elevational ranges.—Revisiting elevational data decades after the initial survey can potentially reveal shifts in the distribution of bird species (Fjeldså *et al*. 2023). My resurvey of elevational distributions of Bougainville's birds on Mt. Balbi in 2022, 50 years after Diamond (1975), resulted in records of many species at higher elevations than previously (Fig. 2).

Finding new maxima for 12 montane species was unsurprising, as these records mainly reflect the lack of prior visits to higher elevations (both Diamond and Hadden reached only *c*.2,000 m). The same applies to some rare species such as Bougainville Bush Warbler or Bougainville Thrush, which are generally poorly documented. However, the new records improve our knowledge of their distributions.

On the other hand, some of the species found at higher elevations than recorded previously are common and widespread with upper range limits below the highest points reached by Diamond (1975) and others (Hamlin 1928, Schodde 1977, Hadden 1981, 2004) (Table 1). This even includes conspicuous species for which many records were obtained by my study, such as Yellow-throated White-eye (n = 141) and Long-tailed Myna (n = 138). The latter was described as 'one of the most conspicuous birds of the lowland forest' (Mayr 1978: 265). It is difficult to imagine that previous researchers, familiar with these species, overlooked them.

Furthermore, the range overlap between the endemic, montane-distributed Bougainville White-eye and its congener Yellow-throated White-eye was recorded as 1,250–1,350 m on Mt. Balbi (Fig. 2), in contrast to previous data, which placed this zone at *c*.900 m. Both species are easily identified in the field by their calls and active behaviour. They forage in flocks and vocalise almost constantly. It appears very unlikely either that former observers overlooked them or that Bougainville White-eye was present but not recorded below 1,250 m during my survey on Mt. Balbi. A possible cause could be habitat alteration at lower elevations, to which Bougainville White-eye may be vulnerable, whereas its congener is known to tolerate this and could therefore have expanded upslope. However, this needs investigation, as anthropogenic impact on forests on Mt. Balbi between 900 and 1,250 m seemed rather low.

Other possible reasons for the large number of species found at higher elevations are poor weather during previous studies (Diamond 1975, Schodde 1977), difficulties in accurately determining elevation in earlier studies, or the overall patchiness of previous data (Table 1).

J. Diamond explicitly mentioned poor weather during his work on Mt. Balbi, with almost uninterrupted rain while he was above 900 m (Diamond 1975). Similarly, Schodde (1977) was unable to establish a camp in cloud forest due to heavy rain and had to conduct daily marches from a lower camp to sample the montane avifauna. During his survey, conditions were fine from dawn until early afternoon, and heavy rain did not start until 12.30–14:30 h. While many birds were active in light rain, all activity ceased during the heavy afternoon thunderstorms. It is therefore conceivable that weather conditions may have limited the efficacy of some prior studies, although Hadden (2004) did not mention such adversities and Diamond (1975) recorded a good number of species above 900 m despite the continuous rain (Fig. 2).

Difficulties in determining elevation during previous studies cannot explain the observed differences of several hundred metres in the distribution of some species. It is not always clear how previous researchers obtained elevation data in the field. Hamlin and

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other WSSE members used an aneroid barometer. The height of the summit of Mt. Balbi was measured very accurately as 8,900 ft. (= 2,713 m) (Hamlin 1929) compared to 2,712 m from SRTM data (NOAA 1999). Of course, minor differences between historical and modern data are likely. For example, using topographic maps published in the 1960s (Royal Australian Survey Corps 1966a,b), elevations were reported as being significantly lower in places (e.g. Lake Loloru on old map: 1,400 m; SRTM: 1,530 m), but elsewhere these maps are more accurate (e.g. Keriaka Camp on old map: 1,255 m, using SRTM: 1,260 m).

Determining lower range limits for species is more challenging than obtaining new upper range data. It is evident that the lowest elevations at which most species were found during my study was not their lower range limit. Sites visited at lower elevations were often affected by anthropogenic factors, making it difficult to determine the species' elevational distribution under natural conditions. In the past, several forest species occurred at suitable sites near the coast. For example, at Torokina, Cockerell's Fantail, Solomons Pied Monarch and Bougainville Monarch, and at the Jaba River delta, Mackinlay's Cuckoo-Dove (Baker 1948). However, in my study these forest specialists were under-represented at lower elevations, but generalists such as Solomons Cockatoo and Yellow-throated White-eye were common there (Fig. 2).

Conservation.—The new elevation data are also important for conservation. The presence of many species at higher elevations than previously known reduces their vulnerability to ongoing human alteration of lower-elevation forest habitats. This may be especially important for species dependent on natural forests (e.g. Mackinlay's and Crested Cuckoo-Doves, Solomons Pied Monarch, Bougainville Monarch and Bougainville White-eye), which can be absent from habitats with even low levels of human disturbance.

Further studies should also focus on possible elevational shifts, as observed elsewhere. On Mt. Karimui, Chimbu Province, Papua New Guinea, significant upward shifts were found in 2014 compared to an earlier survey in 1965 (Freeman & Class Freeman 2014). Montane species are particularly vulnerable to elevational range shifts caused by anthropogenic climate change (Freeman *et al*. 2018).

Overall, most species still occur in good numbers on Bougainville (Table 4) and montane forest still covers large areas. However, the lowlands and lower hills are increasingly being exploited across many parts of the island, and deforestation could accelerate rapidly if Bougainville becomes independent in the near future. Logging companies, which operate extensively on the nearby Solomon Islands (Katovai *et al*. 2015), could provide an income for the new nation. And, while the Panguna mine was closed decades ago, uncontrolled gold mining has spread rapidly around the town in recent years, devastating parts of the upper Crown Prince Range at Kupei, the site where the WSSE collected (Hamlin 1928). There are also plans to reopen Panguna mine in the near future as an integral part of the island government's 'Independence Ready Agenda'.

Other threats include introduced species such as pigs, dogs and cats, which roam freely even in apparently pristine forest. It is unclear if the abundance of introduced species decreases at higher elevations, where steep terrain and heavy rainfall may be limiting factors. However, a recent survey on Kolombangara Island found feral cats at all elevations (Pikacha & Sirikolo 2010). Cane Toad *Rhinella marina* is especially abundant around Torokina, with hundreds observed on roads. In coastal areas and at least up to *c*.1,000 m, Little Fire Ant *Wasmannia auropunctata* is widespread and has probably had a negative impact on the local avifauna since its introduction at least *c*.25 years ago. The rarity of some ground-dwelling birds such as Yellow-legged Pigeon *Columba pallidiceps* or Black-faced Pitta *Pitta anerythra* may be due to threats from non-native predators or competition for food resources.

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Hunting of birds appears almost non-existent, given vital birdlife present even in villages, with the exception of the Panguna area, where hunting of pigeons, doves, parrots, kingfishers and the like is common. Parrots such as Papuan Eclectus and Solomons Cockatoo are sometimes kept as pets. Two Papuan Hornbills were seen in captivity at Asitaipa village.

Conclusion.—It seems unlikely that my results universally represent elevational shifts, but rather are more reflective of the overall patchiness of previous data as well as increasing human influence at lower elevations. However, my study presents new data on the elevational distribution of birds at Mt. Balbi, the highest point in the Solomons. Supplemented by records from other parts of Bougainville and Buka, as well as density estimates for many rarely recorded birds, these results contribute to a better understanding and provide a baseline for future studies. Given the substantial area at higher elevations on Bougainville, the large number of endemic species restricted to this area, and current or future threats such as climate change, uncontrolled mining in the Crown Prince Range around Panguna, and expected deforestation following Bougainville's independence, further research is needed. Next steps could include searching for forest species at suitable lowland sites and more thorough surveys at elevations where congeneric species replace each other.

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Address: Egon-Erwin-Kisch-Str. 26, 01069 Dresden, Germany, e-mail: jan-uwe.schmidt@gmx.de

Appendix 1: villages and other localities.

Name	Latitude	Latitude	Elevation (SRTM)
Asitaipa	-6.07580	154.97323	625
Boruoma Hill	-6.29243	155.47277	1,071
Keriaka camp	-6.02405	154.98939	1,260

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Mt. Balbi camp 0	-5.93999	155.03928	1,284
Mt. Balbi camp 1	-5.93257	155.02048	1,999
Mt. Balbi camp 3	-5.92813	154.99709	2,435
Panguna	-6.30461	155.48854	627
Piva	-6.20961	155.06781	33
Poritai	-6.15626	155.05429	105
Puriri	-6.00171	155.02769	978
Sisivi	-6.00309	155.07635	771
Togarao	-5.96033	155.07924	622
Torokina	-6.24670	155.04126	4
Torokina airfield	-6.20100	155.06099	37
Tutupei	-6.10376	154.96235	16
Uriora	-5.96658	155.07743	534

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