Diversity of Mangrove Flora of Marau, Solomon Islands

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Abstract

Mangrove ecosystems have attracted increasing global attention for their vital ecosystem services and exceptional carbon storage capacity. This study assessed and updated the species composition and population structure of two mangrove forests in the Marau Sound region of Guadalcanal, Solomon Islands. Circular plots (7 m radius) were established at 25-meter intervals along transects running from the seaward to the landward edge of the forests to capture representative ecological data. The primary aim was to determine the current diversity of true mangrove species in the region. A total of 12 true mangrove species were recorded within the study plots, though observations outside the plots suggest the number could reach up to 26. The Rhizophoraceaefamily was found to be the most dominant, with *Bruguiera gymnorrhiza* and *Rhizophora apiculata*identified as the most ecologically significant species. Notably, the study confirmed the presence of *Sonneratia alba* and *Heritiera littoralis*, two species not previously documented in Marau, thus contributing a valuable update to the regional mangrove inventory. These findings highlight Marau as a critical mangrove habitat with species that offer significant potential for blue carbon sequestration, emphasizing the need for continued research and conservation efforts in the region.

1. Introduction

Mangroves are coastal forests that inhabit the narrow intertidal zone between the ocean and dry land. They thrive in warm tropical and subtropical regions, particularly in sheltered waters such as river mouths and lagoons (Amarasinghe & Perera, 2017; Tomlinson, 2016), which allow sediment to accumulate and provide anchorage for mangroves (Irawan et al., 2021; Robert et al., 2015). The mangrove vegetation includes trees, shrubs, a palm and a ground fern (N. C. Duke et al., 1998). There are only an estimated 70 species of true mangroves from 27 diverse genera (N. C. Duke et al., 1998; A. M. Ellison et al., 1999), which share a number of convergent adaptations such as aerial roots, thick leathery leaves, viviparous seedlings etc., (N. C. Duke et al., 1998; A. M. Ellison et al., 1999; Srikanth et al., 2016). Another class of mangrove plants is known as mangrove associates. These are also found in mangal areas but can also be found in other environments such as non- mangrove coastal (Mitra, 2019). Mangrove forests also exhibit a commonly recognized coastward-landward spatial distribution or zonation of mangrove species (Chowdhury et al., 2019; Irawan et al., 2021) which is related to the existence of salinity gradients in the intertidal zone (Castañeda-Moya et al., 2013; Kathiresan & Bingham, 2001).

Mangroves are found in many countries of the tropical and subtropical regions of the Earth (D. Alongi, 2002; Chandra et al., 2010; Ricklefs & Latham, 1993) with many studies pointing to the Indo-west Pacific (IWP) as the point of origin of the greater number of mangrove species as opposed to the Atlantic east Pacific (AEP)(N. Duke, 2017; Ricklefs & Latham, 1993). Much of the colonization by mangroves of Papua New Guinea and the Western Pacific seems to have originated from the Indo-west Pacific (IWP) (N. Duke, 2017; Ricklefs & Latham, 1993; Saenger et al., 2019a). The largest and most biodiverse mangrove forests in the Pacific are concentrated in Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia, Fiji and Micronesia (Allen et al., 2001; Avtar et al., 2021; Woodroffe, 1987a). Some of the commonly shared mangrove genera between these Pacific regions and the southeast Asia and Indian Ocean include members of the *Rhizophora, Bruguiera Avicennia, Sonneratia, Xylocarpus, and Lumnitzera* (N. C. Duke et al., 2012; Woodroffe, 1987b) .

1.1 Mangroves in Solomon Islands

Solomon Islands is known for its high biodiversity and endemism, being situated within the Indo-West Pacific, the most biogeographically diverse region in the world and a major biodiversity hotspot (D. Alongi, 2002; Amarasinghe & Perera, 2017; N. C. Duke et al., 1998; Saenger et al., 2019b). The islands are located between 5° and 12° south latitude and from 155° and 169° east longitude. The mangrove biota of Solomon Islands benefits from, and closely reflects, the mangrove biota of South East Asia and Papua New Guinea, due to its closeness to these two regions(N. C. Duke et al., 2012). Additionally, the low latitude, consistently high temperatures and abundance of islands in this region create ideal conditions for the colonization and growth of mangrove forests (N. Duke, 2017).

Almost half a century ago, Solomon Islands had an estimated total mangrove coverage of 64,200 hectares (Hansell et al., 1976). Mangrove forests are found on most of the large islands (Pillai & Sirikolo, 2001a), covering 2 to 3 percent (Pillai & Sirikolo, 2001b) of the total land area in Solomon Islands. A more recent estimate by Bhattarai (2011) using Landsat imagery puts this figure at around 47,099 hectares (Bhattarai, 2011). The total mangrove coverage may have changed due to anthropogenic pressure, extreme weather and tsunami events (Bhattarai, 2011).

In spite of the extensive mangrove presence, the exact number of mangrove species present in Solomon Islands is still a matter of debate. For example, Woodroffe (1987) and Ellison (2018) identified 19 species (J. C. Ellison, 2018; Woodroffe, 1987b), while Pillai and Sirikolo (2001) recognized 26 true mangrove species from 13 families (Pillai & Sirikolo, 2001a). Duke et al (2012) suggest that there are 31 Solomon Islands mangrove species with eight additional ones (N. C. Duke et al., 2012). Such variability in the number of species may be due to differences in the definition of mangroves and, more particularly, a lack of extensive, in-depth study into the mangrove biota of Solomon Islands (Woodroffe, 1987a).

1.2 Mangroves of Guadalcanal

The island of Guadalcanal lies in an east-south-east to west-north-west direction. This orientation exposes the southern coastline and mangrove dominated Marau Sound on the south-eastern tip directly to the south-easterly trade winds. The constant battering by high-energy waves along the southern coast prevents mangrove colonization (Pillai & Sirikolo, 2001a). However, despite Marau Sound's exposure, the south-eastern tip of the island is protected by numerous small islets and stretches of barrier reef systems, creating sheltered coastlines where mangroves can thrive. Marau Sound stands as the primary mangrove region on Guadalcanal.

Pillai and Sirikolo (2001) inventoried mangroves of Solomons archipelago in the early 2000s and their mangrove inventory is still being used as an important reference material for mangrove studies in Solomon Islands. However, in their 2001 survey of Marau Sound, Pillai and Sirikolo only documented 11 species of true mangroves; *R. stylosa, R. apiculata, B. gymnorrhiza, L. littorea, R. mucronata, Bruguiera parviflora, Ceriops tagal, Sonneratia ovata, Excoecaria agallocha, Xylocarpus granatum, and Scyphiphora hydrophyllacea*, (Pillai & Sirikolo, 2001a). Pillai and Sirikolo surveyed three islets and two sites on the mainland of Marau, one of which (Savekau) was also surveyed in this study. However, their mangrove inventory of Guadalcanal was limited to the northern side of Marau Sound and did not capture the mangrove flora on the southern side of that region.

This study aims to investigate the diversity of mangrove flora of Marau Sound and to update the local mangrove species inventory of that region of Guadalcanal by including the previously unsurveyed Kopiu mangrove forest.

2. Materials and Methods

2.1 Study sites

This study was carried out in Marau Sound on the Island of Guadalcanal (Fig. 1) in the Solomon Islands group, which is located between the latitudes of 11^{o} 44' and 6^{o} 57' S and the longitudes of 167^{o} 3' and 155^{o} 43' E. The two study sites, namely Kopiu and Savekau were selected to represent two geographically distinct sides of the island. The first site, Kopiu, is located on the southern coast (9^{o} 53' S, 160^{o} 46' E) and faces south towards the open sea. The second site, Savekau, is located on the northern coast (11^{o} 44'S, 155^{o} 43' E), and is more sheltered with smaller islets guarding it. The two sites are approximately 10.5 km apart and separated by a mountain range that rises to over 300 m steeply above Kopiu and gradually sloping down toward Savekau on the other side.

2.2 Sampling and data collection

Following Ellison (2012), prior to the field survey, the two study sites were identified using Google Earth(J. Ellison, 2012) (Google Earth, 2023) and copies of the maps of the sites made. A Google Earth detectable stream each were identified in both study sites. The streams became the landmarks for easy identification of the study sites and the placement of the starting points of our transects. With the help of local guides, and the GPS, the starting and end points for the transects were located on the ground to ensure that the transects are parallel. Since the streams run approximately perpendicular to the coastline, and at about the center of each study site, we used the streams as convenient reference points for guiding our first transects, following Ellison (2012). The other transects were sequentially added to the left and right of the first, separated by a 50-meter interval (as accurately as the situation allows) (J. Ellison, 2012; Kauffman & Donato, 2012) and numbered 1–4 from the left to the right, facing landward. The last mangrove plant at the seaward edge of the forest became the starting point for each transect (J. Ellison, 2012).

The design and layout of our plots, as much as possible, followed Kauffman and Donato (2012) while also acknowledging that Kauffman and Donato (2012) mentioned that plot designs could be modified with the prime objective of accurately describing the forest while at the same time ensuring safety (Kauffman & Donato, 2012). Thus, our transect lines were drawn, using a 100-meter tape, from the seaward edge of the mangrove forests to the uplands (Kauffman & Donato, 2012). Circular sampling plots were laid out along each transect at 25-meter intervals. Each circular plot had a radius of seven meters (Kauffman & Donato, 2012) (area = 153.9 m^2), with the number of plots varying between 9 and 16, depending on the length of the transects. All mangroves and mangrove associates within the circular plots were counted, identified to the species level. Mangrove species spotted outside of the transects and survey plots were identified but not counted. During the survey, 50 plots (total area = 7695m^2) were surveyed in the Kopiu mangrove forest and 46 plots (total area = 7,079m^2) in Savekau.

2.3 Mangrove Species Identification

Mangrove flora in the Kopiu and Savekau study sites were identified to the species level on site using mangrove manual *'Mangroves of Solomon Islands'*, by Pillai and Sirikolo, 2001, and the expertise of forestry officer and co-author of the afore mentioned mangrove inventory, Myknee Sirikolo.

2.4 Species Composition and Importance Value

Following Vijayan (2015), mangrove species were identified counted and measured (DBH and height) in the study plots in the two study sites. The data gathered was used to investigate the pattern of distribution and population structure among the mangroves by establishing a quantitative relationship among plant species using the following indexes: relative frequency (RF), relative density (RD), relative dominance (RDom), abundance (A), abundance to frequency ratio (A/F ratio) and importance value index (IVI) (Hondappanavar et al., 2024). The sum of RF, RDom and RD is the IVI (Hondappanavar et al., 2024; Vijayan, 2015).

IVI = relative density (RD) + relative frequency (RF) + relative dominance (RDom)

$$\mathrm{RD} = (Total\ number\ of\ individuals\ of\ species\ i) \,/\, (\text{Total number all individuals of all species }) \text{ x } 100$$

$$\mathrm{RF} = (\text{frequency of species } i \text{ }) \,/\, (\text{Sum of frequencies of all species}) \text{ x } 100$$

$$\mathrm{Rdom} = (Total\ basal\ area\ ofspecies\ i) \,/\, (Basal\ area\ of\ all\ species\ ) \text{ x } 100$$

These indices were calculated using Microsoft Excel version 2018.

The non-woody mangrove fern *Acrostichum speciosum* was excluded from basal area measurement because it has no measurable basal area at the required height of 1.3 m (Snedaker & Snedaker, 1984). Thus, its IVI is the sum of its relative frequency and relative density only.

2.5 Species Diversity

Alpha (α) diversity between the two mangrove forests was assessed using species evenness (Pielou's evenness index), richness (Margalef's richness index) and heterogeneity (Shannon-Weiner and Simpson's indexes (1-D) (Hondappanavar et al., 2024). Rank-abundance curves were generated for both forests using relative abundance data to visualize patterns of species richness and evenness across the two sites (Kiernan, 2014). To evaluate compositional similarity or beta diversity, both the Jaccard index and Bray-Curtis dissimilarity indexes were also calculated (Kiernan, 2014).

Pielou's evenness index: $J\prime = H\prime / (ln(S\,))$

Where H' is the Shannon-Weiner index and *S* is the total number of species.

Margalef's richness index: $R = (S - 1)/ln⟦(N)⟧$

Where S is the total number of species or species richness and N is the total number of individuals (I) the sample.

Shannon-Weiner index: $H' = -\sum_{i=1}^{s}(pi * lnpi)$

Where H' is the species diversity index, *s* is the number of species, *pi* is the number of individuals of each species, and *ln pi* is the natural log of *pi.*

Simpson's index (1-D):

$$D = 1 - (\Sigma\, n(\,n - 1\,))\,/\,(N(\,N - 1\,))$$

Where n is the number of all the members of one species, and N is the number of members of all the species in the area.

Bray-Curtis Similarity Index: $BCij = 1 - 2\left(Cij\right)/\left(Si + Sj\right)$

Where:

BCij = Bray - Curtis index

Cij = Sum of the minimum values of each species' abundance between the two samples

Si = Total abundance of all species in sample i

Sj = Total abundance of all species in sample j

(Apacible Tc & Pereda Lt, 2015; Baleta & Casalamitao, 2016; Hondappanavar et al., 2024)

Jaccard Index

SJ = c / (a + b + c)

Where:

SJ = similarity index,

c = number of shared species between the two sites

a and *b* are the number of species unique to each site.

3. Results

3.1 Composition of Mangrove flora

Twelve mangrove species, both true and associates, from eight families and ten genera (Table 1) were recorded in the study plots in the two forests of Savekau and Kopiu. Other mangroves and associates were also sighted in the surrounding areas outside of the survey plots, (Table 1). Kopiu exhibited the highest number of mangrove species observed in the survey plots with 11 species (10 true mangroves and one associate). Savekau showed only six true mangrove species and no associates. The species *Bruguiera gymnorrhiza*, *Bruguiera parviflora*, *Ceriops tagal*, *Rhizophora apiculata* and *Rhizophora stylosa* occurred in both Kopiu and Savekau.

Rhizophoraceae was the largest mangrove family with five representative species. When considering all the mangrove plants sighted in the survey plots, the Rhizophoraceae family accounted for approximately 81.6% of the sightings.

The mangrove assemblages and the substrate observed at the two study locations are outlined thus:

Study site 1 – Kopiu

The Kopiu forest begins with the mangrove species *Sonneratia alba* growing on the seaward edge of the coral and sand bed, within the intertidal zone, and extends landward until it meets a narrow zone of *Rhizophora apiculata*. After the *Rhysophora* zone the forest transitions into a mixed to nearly pure stands of *B. gymnorrhiza*. The most landward zone in Kopiu is characterized by the presence of *Heritiera littoralis*. The only mangrove palm, *Nipa fruticans* was seen growing at the edge of a pool, at the landward edge of the forest. The mangrove fern *Acrostichum speciosum* was also observed in one study plot where some mangroves had been cleared.

The substrate in this forest is varied beginning with dead coral, with mixed sand and silt in the midsection of the forest. Large pieces of dead coral are also observed in many places within the forest. In areas close to the small stream which supplies fresh water to the mangroves, the substrate is almost purely silt and, in some places, may be more than a meter deep. The top soil is also covered by a layer of dead leaves and branches.

Table 1
True mangroves and associates of Kopiu and Savekau study sites and the surrounding vicinity.

	Scientific name	Plant status	Location	
			Kopiu	Savekau
Mangroves sighted within study plots only				
1.	*Acrostichum speciosum*	Fern	+	
2.	*Bruguiera gymnorrhiza*	Tree	+	+
3.	*Bruguiera parviflora*	Tree	+	+
4.	*Ceriops tagal*	Tree	+	+
5.	*Dolichandrone spathacea*	Tree	+	
6.	*Heritiera littoralis*	Tree	+	+
7.	*Inocarpus fagifer**	Tree	+	
8.	*Lumnitzera littorea*	Tree	+	
9.	*Rhizophora apiculata*	Tree	+	+
10.	*Rhizophora stylosa*	Tree		+
11.	*Sonneratia alba*	Tree	+	
12.	*Xylocarpus granatum*	Tree	+	
Mangroves sighted in the general vicinity of the Marau Sound region apart from study plots.				
13.	*Acanthus ebracteatus*	Shrub	+	+
14.	*Aegicerus corniculatum*	Shrub	+	+
15.	*Avicennia marina*	Tree	+	+
16.	*Barringtonia racemosa*	Tree	+	+
17.	*Clerodendrum inerme**	Shrub		+
18.	*Cynometra ramiflora**	Tree		+
19.	*Excoecaria agallocha*	Tree	+	+
20.	*Hibiscus tiliaceus**	Tree	+	+
21.	*Myristica hollrungii**	Tree		+
22.	*Nypa fruticans*	Palm	+	+
23.	*Rhizophora x lamarckii***	Tree	+	+
24.	*Samadera (Quassia) indica**	Tree		+
25.	*Scyphiphora hydrophyllacea*	Shrub	+	+
26.	*Sonneratia caseolaris*	Tree		+

* Mangrove associates; **Mangrove hybrid.

Study site 2 - Savekau

The Savekau forest starts with a *Rhizophora* zone, the most seaward zone in Savekau reaches up to about 200 meters inland from the edge of the ocean in some places. The *Rhizophora* stand forms an impenetrable barrier at the edge of the mangrove with its dense network of stilt roots. This then transitions into the *Bruguiera gymnorrhiza* zone. A few *H. littoralis* specimen mark the landward edge of the forest. The Savekau mangrove forest is dominated by two species, *Rhizophora apiculata* and *Bruguiera gymnorrhiza*.

The substrate in this zone consists mainly of mud, with minimal sand content, and is saturated with organic matter. It appears to be deeper here than in Kopiu and is heavy with the characteristic sulfurous odor of the typical of mangrove swamps. Leaf litter forms the surface layer.

Vegetation Structure and Importance Value

Study site 1 – Kopiu

A total of 276 mangrove plants, from eleven species were recorded in the survey plots at Kopiu (Table 2). *B. gymnorrhiza* was the most frequently encountered species in the Kopiu mangrove forest, occurring in 33.72% of all plots surveyed. It also exhibited the highest density (30.43%) and was the most dominant mangrove species, accounting for 81.6% of the total basal area. The low abundance-to-frequency (A/F) ratio of 0.1 indicates that *B. gymnorrhiza* is evenly distributed across the forest. Its Importance Value Index (IVI) of 145.84 shows that it is the most important mangrove flora in Kopiu.

The second most important species was *R. apiculata*, with an IVI of 56.62. This species also showed an even distribution across the survey area, as evidenced by its low A/F ratio of 0.12.

Sonneratia alba ranked third, with a relative density of 18.48% and an IVI of 31.17. Unlike *B. gymnorrhiza* and *R. apiculata*, however, *S. alba* and most of the other mangrove species recorded A/F ratios equal to or greater than 0.5, suggesting a clumped distribution pattern, rather than even distribution within the forest.

The three species, *A. speciosum*, *L. littorea* and *I. fagifer* all exhibited the lowest relative frequency (1.16), with each species detected only in one study plot, indicating a very restricted distribution with in the mangrove forest. *I. fagifer* is classified as a mangrove associate.

Table 2
The community composition and structure of Kopiu mangrove forest.

Kopiu Mangrove Species	Frequency	Relative Frequency	Population Density	Relative Density (%)	Dominance	Relative Dominance	Abundance	A/F	IVI
B. gymnorrhiza	29	33.72	124.02	30.43	26.92	81.68	2.90	0.10	145.84
R. apiculata	23	26.74	97.44	23.91	1.96	5.96	2.87	0.12	56.62
S. alba	9	10.47	75.30	18.48	0.73	2.23	5.67	0.63	31.17
D. spathacea	4	4.65	22.15	5.43	2.02	6.14	3.75	0.94	16.23
B. parviflora	8	9.30	23.62	5.80	0.21	0.63	2.00	0.25	15.73
H. littoralis	5	5.81	14.76	3.62	0.64	1.94	2.00	0.40	11.37
A. speciosum	1	1.16	31.00	7.61	0.00*	0.00*	21.00	21.00	8.77
C. tagal	3	3.49	7.38	1.81	0.17	0.50	1.67	0.56	5.80
X. granatum	2	2.33	2.95	0.72	0.10	0.29	1.00	0.50	3.34
L. littorea	1	1.16	7.38	1.81	0.03	0.10	5.00	5.00	3.08
I. fagifer	1	1.16	1.48	0.36	0.17	0.53	1.00	1.00	2.05
Total	86	100	407.48	100	32.96	100			300

*For *A. speciosum*, the values for Dominance and Relative Dominance = 0 because there is no measurable basal area at 1.3 m (DBH).

Study Site 2 – Savekau

A total of 304 mangrove plants were recorded across the 46 plots surveyed in the Savekau forest. These individuals belong to six mangrove species, as shown in Table 3. From our results, *B. gymnorrhiza* was the most important species followed by *R. apiculata* with IVI values of 145.74 and 107.48 respectively. *R. stylosa*, *C. tagal* and *B. parviflora* followed with comparable IVIs of 14.43, 14.36 and 12.61. *H. littoralis* had the lowest IVI of 5.37.

B. gymnorrhiza was also the most dominant species in this forest (relative dominance = 57.92), although *R. apiculata*, *R. stylosa* and *C. tagal* had higher abundance values, 4.41, 5.25 and 4.00 respectively. *B. gymnorrhiza*, *R. apiculata* and *C. tagal* exhibited low abundance-to-frequency ratios (A/F < 0.5) while *R. stylosa*, *C. tagal* and *H. littoralis* showed higher A/F values of over 0.5.

Table 3
The community composition and structure of the Savekau mangrove forest.

Savekau Mangrove Species	Frequency	Relative Frequency	Population Density	Relative Density (%)	Dominance	Relative Dominance	Abundance	A/F	IVI
B. gymnorrhiza	34	44.74	185.00	43.09	12.20	57.92	3.85	0.11	145.74
R. apiculata	27	35.53	168.05	39.14	6.91	32.81	4.41	0.16	107.48
R. stylosa	4	5.26	29.66	6.91	0.48	2.26	5.25	1.31	14.43
C. tagal	5	6.58	28.24	6.58	0.25	1.20	4.00	0.80	14.36
B. parviflora	5	6.58	15.53	3.62	0.51	2.41	2.20	0.44	12.61
H. littoralis	1	1.32	2.82	0.66	0.72	3.40	2.00	2.00	5.37
Total	76	100	429.30	100	21.06	100			300

3.2 Alpha (α) Diversity

Our evaluation of alpha diversity between the two forests showed Kopiu having higher diversity across all metrics. It had a Margalef's richness index of 1.78, compared to 0.87 in Savekau. Kopiu also exhibited higher Shannon-Wiener diversity (H' = I.86) and Simpson's index (1-D = 0.8) than Savekau (H' = 1.25, 1-D = 0.65). Species evenness was also higher in Kopiu (Pielou's J = 0.77) than in Savekau (Pielou's J = 0.696).

Table 4
Alpha diversity indexes of Kopiu and Savekau. Kopiu shows a diversity across all metrices.

	Shannon-Weiner diversity index	Simpson's index of Diversity (1-D)	H max	Pielou's evenness (J)	Margalef's index
Kopiu	1.86	0.80	2.40	0.77	1.78
Savekau	1.25	0.65	1.79	0.70	0.87

3.3 Rank-Abundance Patterns

Rank-abundance plots were also constructed for the two forests. The values on the Y axis were transformed (log 10) to magnify the differences among less abundant species (Curran-Everett, 2018). The curve for Kopiu was longer and had a gentler slope in contrast to the curve for Savekau which was shorter and steeper.

3.4 Beta diversity between Kopiu and Savekau

The Jaccard index based on shared species presence, which is 5 out of 12, revealed a similarity index of approximately 0.42. The Bray-Curtis dissimilarity index also yielded a value of approximately 0.42.

4. Discussion

Mangroves form a limited group of flora (D. M. Alongi, 2008). This low diversity may be indicative of the harshness of the environmental conditions in which mangroves evolved (N. C. Duke et al., 1998). According to Pillai and Sirikolo (2001), Solomon Islands has 26 mangrove species which is approximately 43% of the world's mangroves. This relatively rich mangrove flora may be due Solomon Islands geographical location within the East Melanesia Biodiversity Hotspot and the IWP, a major global biodiversity hotspot (D. Alongi, 2002; Amarasinghe & Perera, 2017; N. C. Duke et al., 1998; Saenger et al., 2019b), and center of mangrove diversity (Goulding & Dayrat, 2023).

The two forests surveyed are situated on opposite sides of the eastern tip of Guadalcanal, also known as Marau Sound, allowing for a comparative analysis of forest structure and species diversity across this geographical divide. Additionally, the study offers opportunity to update the mangrove species inventory for the region, building on the earlier work of Pillai and Sirikolo (2001). which gives this study the opportunity to examine mangrove forests on opposing sides of

4.1 Important Mangrove Families of Marau

Marau region is clearly dominated by the mangrove family *Rhizophoraceae*, with two of its members, *B. gymnorrhiza and R. apiculata* being the two most important species identified by our survey in the Marau Sound region. This confirms their local ecological dominance and possibly their broader adaptability. *B. gymnorrhiza* is the most widespread of the mangroves in the Pacific region (N. C. Duke et al., 1998).

In Marau region, members of the genus *Rhizophora* form almost impenetrable coastal barriers in many places. The *Rhizophora* genus plays key ecological roles in the mangrove and marine ecosystems. Its stilt roots and muddy substrates provide habitat for meiofauna, which are important food source for fish and crustaceans. The roots also serve as nurseries, offering shelter for juvenile fish and crustaceans until they migrate to coral reefs or other habitats (Abu El-Regal & Ibrahim, 2014; Laegdsgaard & Johnson, 1995; Nagelkerken et al., 2008). In addition, *Rhizophora* species help protect shorelines from erosion through their dense, interwoven root systems which stabilize banks and trap sediments (D. M. Alongi, 2008; Duke, N.C, 2006; Kathiresan & Bingham, 2001). This sediment trapping may help mangroves keep pace with sea-level rise (Mackenzie et al., 2013), while retained organics matter supports nutrient cycling by providing carbon and nitrogen to resident bacteria and algae (Kathiresan & Bingham, 2001).

Sonneratia alba was observed only in the Kopiu mangrove forest, suggesting either a limited local distribution or that environmental conditions in the *Savekau* forest are unsuitable for its establishment. *Sonneratia* species prefer sandy or submerged substrates (Irawan et al., 2021), a feature notably absent in Savekau. In contrast, *S. alba* in the Kopiu forest was observed growing on the coral and sandy platform within the tidal zone. Additionally, its restricted dispersal may be attributed to the limited buoyancy of its propagules (Wee et al., 2017).

S. alba plays a very important role in protecting the coral and shoreline from the destructive force of high energy incoming waves. When waves encounter a dense patch of *Sonneratia* spp., their energy is dissipated (Muliddin et al., 2014), greatly reducing damage to coral and enhancing shoreline protection. The presence of *Sonneratia spp*. in Marau intertidal zone is a vital natural form of coastal defense.

4.2 Mangrove Diversity (β) between Kopiu and Savekau

The observed beta diversity between the two mangrove forests reflects a moderate level of species turnover, an indication that each site supports a distinct but partially overlapping mangrove community. The Bray-Curtis dissimilarity index revealed notable differences in species abundances, while the Jaccard index highlighted differences in species composition. These differences likely result from the different environmental conditions such as local topography, salinity, tide and substrate (Djamaluddin et al., 2024; 1999; Irawan et al., 2021), due to the forests being located in two distinct sides of the Marau Sound. The anthropogenic factor is also an important one which could also help to explain these differences.

4.3 Update of mangrove species list for Marau Sound

This study was able to identify 10 species of true mangroves in the mangrove forests of *Kopiu* and *Savekau* in Marau Sound of Guadalcanal Island. Of the 10 species, three (*H. littoralis, Nypa fruticans, Sonneratia alba*) were not previously confirmed or reported in the 2001 list of mangroves of Marau Sound by Pillai and Sirikolo. They mentioned however, their unspecified presence in parts of Guadalcanal. With the new confirmations by this study, the number of true mangroves, (not counting mangrove associates), of Marau Sound now stands at 14 – *R. stylosa, R. apiculata, B. gymnorrhiza, L. littorea, Rhizophora mucronata, Bruguiera parviflora, Ceriops* *tagal, Sonneratia ovata, Excoecaria agallocha, X. granatum, Scyphiphora hydrophyllacea, Heritiera littoralis, Acrostichum speciosum and Sonneratia alba.* If, however, the mangroves observed outside of the study plots (see Table 1) were verified and included, this number could increase.

No endemic mangroves were recorded in the Marau region. However, the 14 confirmed mangrove species highlight Solomon Islands' rich floral diversity and align with the high biodiversity typical of the Indo-West Pacific region (N. C. Duke et al., 1998). With 14 true mangrove species identified in Marau- over half of the 26 species reported for the entire Solomon Islands (Pillai and Sirikolo, 2001), the area stands out as a relatively species-rich and ecologically important mangrove habitat within the national landscape.

4.4 B. gymnorrhiza and Rhizophora: Potential Blue Carbon Mangroves Species in Marau Sound

The abundance of *B. gymnorrhiza* and *R. apiculata* combined with their dense woody structure, could mean that these species are also important carbon sinks. Approximately 54% of the biomass of *B. gymnorrhiza* (K. A. R. S. Perera & Amarasinghe, 2013; Rahman et al., 2021), and 44.1% of *R. apiculata* (Vinh et al., 2019) is composed of carbon. Given their dominance in the Marau region, these species likely contribute substantially to carbon sequestration. This highlights a promising avenue for future research in quantifying mangrove blue carbon stocks in Marau and Solomon Islands.

4.5 Low presence of *Lumnitzera littorea* and *Xylocarpus granatham*

L. littorea is a socio-economically and ecologically important species. *L. littorea* is widespread in the Indo-Pacific and is highly valued for its durable timber. Some of its uses include boat building, construction and firewood (P. L. M. M. Perera et al., 2019) and treatment of various tropical diseases (Madhushanka et al., 2022). Despite its usefulness, the species is often found in small isolated populations and faces significant conservation challenges.

Declines in the *L. littorea* populations have been documented throughout its range. For instance, in Fiji it is rare on the smaller islands of the group (Ellison, J., 2010). In Sri Lanka, it is classified as Critically Endangered (CR) by IUCN due to very low populations (Madhushanka et al., 2022; P. L. M. M. Perera et al., 2019) and in China, its distribution is limited to Hainan Province, where populations are also sparse (Su et al., 2007).

Phylogenetics studies (Guo et al., 2021; Su et al., 2007) identified that habitat fragmentation and population isolation are significant threats to *Lumnitzera* species. Additionally, factors such as low germination rates, seed dormancy, absent embryos and damage by *Gelechiid* moths further endanger *L. littorea* (P. L. M. M. Perera et al., 2019). Without conservation efforts, the species may risk extinction in parts of its range (Gunawardana et al., 2023).

In this study *L. littorea* was recorded only in the *Kopiu* forest and with very low presence, in contrast to Pillai and Sirikolo's (2001) observations, which found it to be one of the more dominant mangrove species in the region. This apparent decline may indicate that the *L. littorea* is facing pressures that threaten its population possibly due to overexploitation of its highly valued timber. These findings underscore the potential vulnerability of this species in Marau and highlight the need for targeted conservation efforts to support its long-term survival.

X. granatham, was also recorded in very low numbers in the Marau region during this study. Although it is widely distributed across the Indo West Pacific region (N. Duke, 2017), the species naturally occurs in low densities within mangrove forests (Robertson et al., 2024), limiting its commercial viability despite the high value of its timber (Robertson et al., 2024). Evidence of past harvesting activities was observed at both Kopiu and Savekau, suggesting local utilization may be contributing to its reduced presence.

Both *X. granatum* and *L. littorea* and other low density mangrove species may have been affected by a combination of natural and anthropogenic disturbances. The decline or loss of mangrove species, not only reduces biodiversity but also undermines essential ecosystem functions, which in turn can negatively impact the livelihoods of communities that depend on mangrove ecosystems (Apacible Tc & Pereda Lt, 2015).

5. Limitations of the study

In this study we identified previously undocumented mangrove species in Kopiu and Savekau mangrove forests in the Marau Sound region of Guadalcanal and consider that more species may remain to be discovered. As a result of remoteness, time and weather constraints during this study, we could not survey a higher number of mangrove sites in Marau Sound. Had this study included more mangrove sites, the list of mangrove flora of the region might be higher than what we have confirmed and that a truer picture of mangrove status of Marau region would be constructed.

6. Conclusion

Although the *Kopiu* and *Savekau* mangrove forests are relatively close to each other, they exhibit significant differences in forest structure and composition. Despite the differences, certain individual species, such as *B. gymnorrhiza* and *R. apiculata* retain their high level of ecological importance across the two forests. Additionally, the number of mangrove species in Marau Sound is now updated and confirmed to be higher than previously reported, with the possibility that more species remain unreported. Also, the population of at least one species, *L. littorea*, has reduced over the past 25 years and may be experiencing serious ecological and anthropogenic pressures. Conversely, the *Rhizophoraceae* family remains abundant and is likely the most important group for mangrove ecosystem services in the Marau Sound region, including coastal protection and carbon sequestration. A future study could investigate the carbon potential of this particular mangrove family in Marau Sound.

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Figures

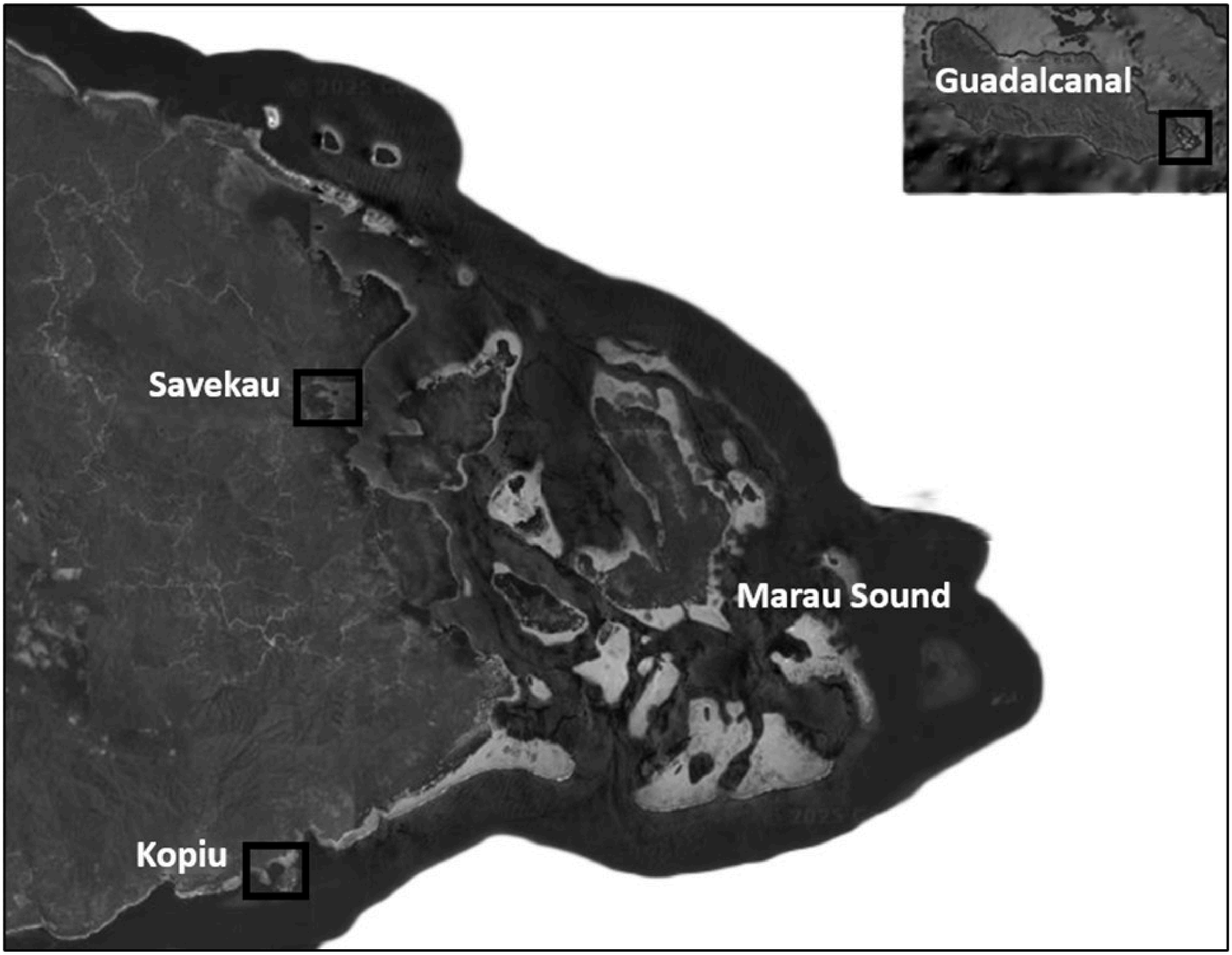

Figure 1

Study sites - Kopiu and Savekau in Marau Sound, on the southeastern tip of the island of Guadalcanal, Solomon Islands

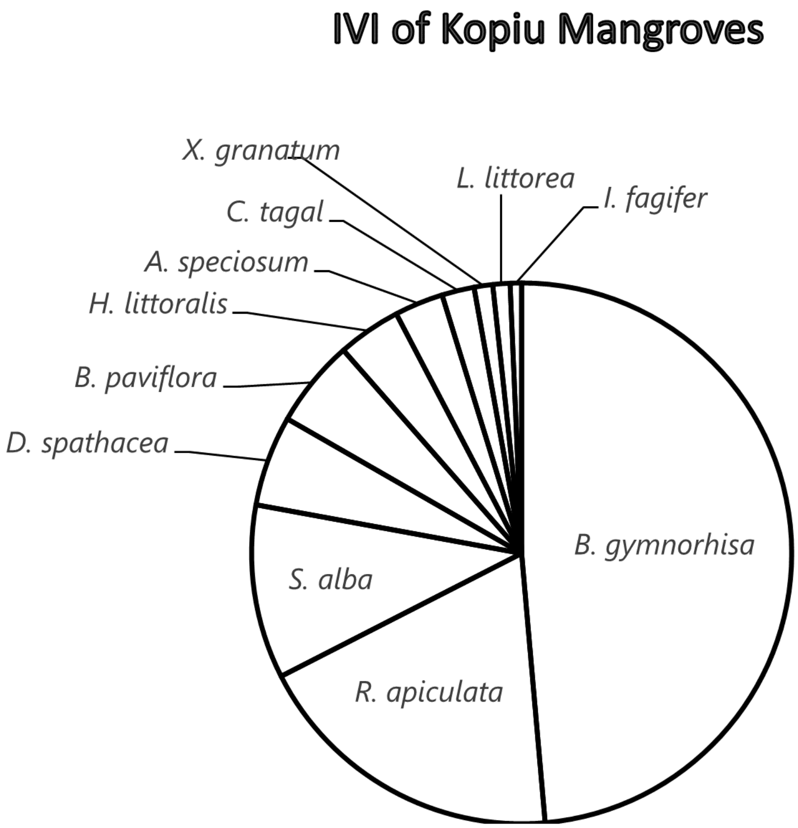

Figure 2

A comparison of importance value indexes of mangrove species in Kopiu. For the IVI values refer to Table 2

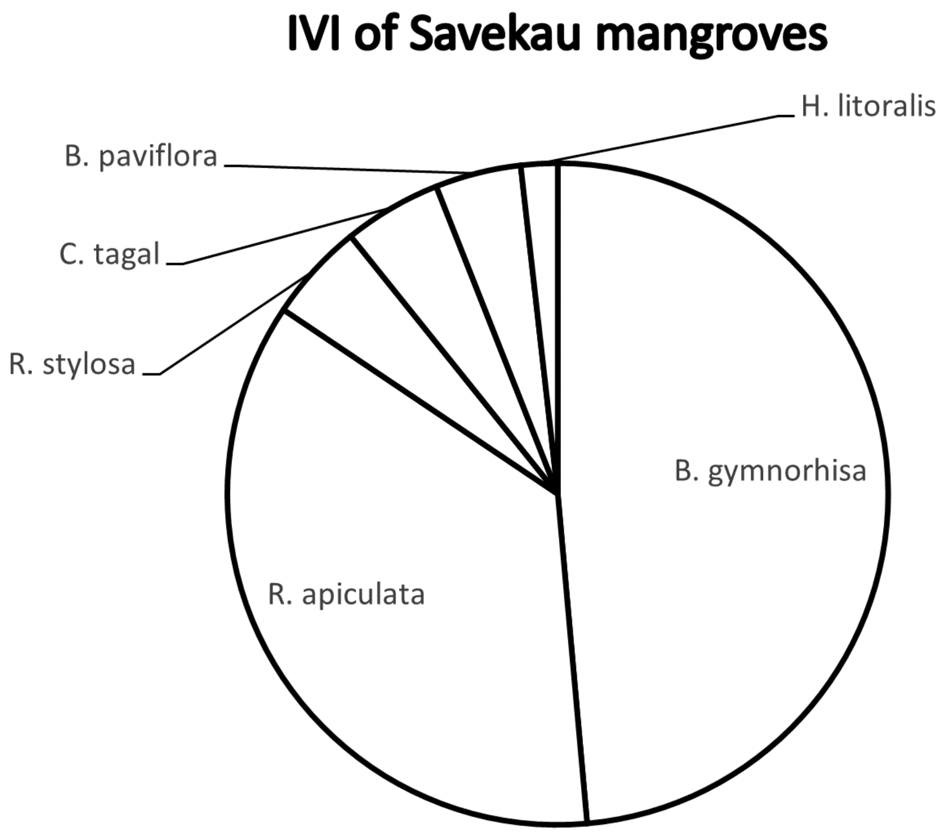

Figure 3

B. gymnorrhiza and R. apiculata strongly dominate the Savekau mangrove forest. For the IVI values see Table 3.

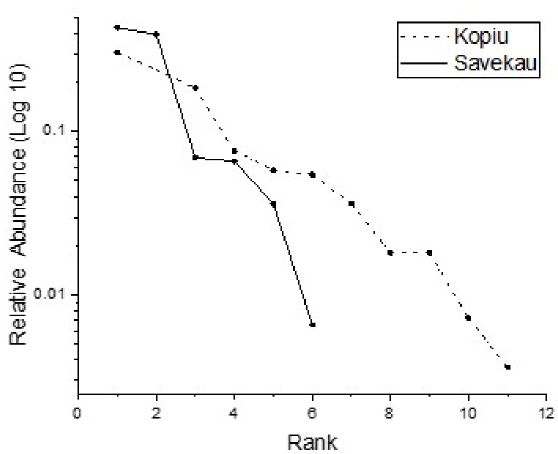

Figure 4

The steep slope of the Savekau graph indicates strong dominance by such species as B. gymnorrhiza and R. apiculata, while the remaining species occur at much lower abundances. The more gradual slope of the Kopiu graph shows a higher species richness and greater evenness among the species observed.