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True Mangroves of Bintuni Bay, Indonesia with Special Notes on the Existence of *Amyema mackayensis* (Blakely) Danser and *Brownlowia argentata* Kurz

Mangrove Sejati di Teluk Bintuni, Indonesia dengan Catatan Khusus terhadap Keberadaan Amyema mackayensis (Blakely) Danser dan Brownlowia argentata Kurz

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ABSTRACT

This research aimed to identify true mangroves in the ecotone area of Bintuni Bay, West Papua, Indonesia. It applied a plotless transect sampling method to identify two true mangroves previously unknown to the area, namely *Amyema mackayensis* and *Brownlowia argentata*. The presence of the species in Bintuni Bay extended its distribution to the northern area of Indonesian New Guinea. With the addition of these two new records, Bintuni Bay hosted 30 species of true mangroves.

INTISARI

Tujuan dari penelitian ini adalah untuk mengidentifikasi spesies mangrove sejati di area ekoton Teluk Bintuni, Papua Barat, Indonesia. Metode sampling transek tanpa plot digunakan pada studi ini untuk mengidentifikasi dua spesies mangrove sejati yang sebelumnya tidak ditemukan di area tersebut, yaitu Amyema mackayensis and Brownlowia argentata. Kehadiran spesies ini di Teluk Bintuni memperluas distribusinya ke area utara New Guinea bagian Indonesia. Dengan dua temuan baru ini, Teluk Bintuni telah memiliki 30 spesies mangrove sejati.

Introduction

In the western corner of West Papua, Indonesia, Bintuni Bay is home to over 220,000 ha of mangrove forests, making it the third-largest mangrove area in the world (Gaveau et al. 2021). The bay provides valuable environmental and economic benefits to the local communities (Ruitenbeek 1992; Wahyudi et al. 2014; Wahyudi 2019). However, its significance goes beyond these benefits. Recent research conducted in the area has revealed that the bay is not just a body of water but a crucial habitat for migratory birds, particularly shorebirds from Palearctic Asia, during the non-breeding season (Yudha et al. 2024). Moreover, as part of the Bird's Head area in mainland New Guinea, Bintuni Bay is home to a significant number of mangrove plant species. This makes the bay one of the world's mangrove biodiversity hot spots, with 28 true species identified out of the 47 recognized in Indonesia (Pribadi 1998; Giesen et al. 2007; Yudha et al. 2021). The rich diversity of mangroves in the area also contributes to New Guinea being recognized as the most floristically diverse island in the world (Cámara-Leret et al. 2020).

Research on the flora and fauna of Bintuni Bay, particularly in the southern part, is regularly conducted by a Forest Management Enterprise (FME) responsible for sustainable timber use in the area (PT BUMWI 2021), focusing on the biodiversity observation of the region, particularly in the production zone, which includes parts of the legally allocated mangrove areas for timber harvesting. The FME also observes the impact of logging on the diversity of flora and fauna of the mangrove forests and the regeneration of mangrove vegetation in logged-over areas (Sillanpää 2017; Yudha et al. 2021; Yudha et al. 2022).

According to research conducted by Kusmana et al. (1997), Pribadi (1998), and Yudha et al. (2021), Bintuni Bay is home to 28 species of true mangrove plants from 11 families. Rhizophoraceae, with nine species, is the most predominant family. Five species - *Bruguiera gymnorhiza*, *Bruguiera parviflora*, *Ceriops tagal*, *Rhizophora apiculata*, and *Rhizophora mucronata* - are particularly abundant in the bay, covering about 93% of the primary mangrove forests. These species are mainly found in the production zone (Yudha et al. 2021) or the interior mangrove zonation (Noor et al. 1999).

The current research conducted in an ecotone area, which serves as a transitional zone between the dry lands (terrestrial forests) and the wetlands (mangrove ecosystem) in the southern part of Bintuni Bay. In this area, mangroves were the dominant vegetation at the highest astronomical tide level, influenced by tides even although frequency of inundation was lower compared to the interior and fringe mangroves zonation. With these characteristics, the ecotone area is often referred to as transitional forest (Adame et al. 2024). Only a few studies have been carried out on this ecotone (e.g., Pribadi 1998; PT BUMWI 2019), with the majority focusing on interior zonation. Therefore, this research aimed to document true mangroves in the ecotone area that were not previously reported within the concession and Bintuni Bay. The findings contributed to the update of the present list of true mangrove species occurring in Bintuni Bay.

Methods

Research Area

This research took place in the southern part of Bintuni Bay, West Papua, Indonesia (Figure 1), within the concession area of PT Bintuni Utama Murni Wood Industries (PT BUMWI), an FME. This research was part of the annual environmental monitoring conducted by the FME to comply with mandatory requirements for monitoring the impacts of FME operations (PT BUMWI 1994). Previous research primarily focused on analyzing forest structure, habitat regeneration, and biodiversity in the production zone, particularly in the logged-over area after harvesting (Yudha et al. 2021). This research targeted the ecotone area, which had rarely been observed for biodiversity monitoring in previous years. The ecotone represents a transitional area where two biomes meet and is predominantly influenced by mangroves affected by tides. This research employed a plotless transect sampling method (Kusmana 2017) involving walking along the ecotone and direct observation without a specific vegetation plot design. Consequently, a detailed structural analysis, including the observed species' abundance, density, and stratum

comparison, was not conducted. The research was carried out in September, November, and December 2019. The observed species were identified, recorded, and photographed using a Nikon COOLPIX P900.

Research Protocol

The term "true mangroves" refers to plant species that are exclusive to mangrove forests and do not grow in terrestrial communities. They play a significant role in the structure of mangrove communities, often forming pure stands, and have specific morphological adaptations for the mangrove environment. Furthermore, true mangroves have mechanisms to exclude salt. According to Giesen et al. (2007), there are 52 true mangrove species, including 42 trees, four epiphytes, three ground herbs, two ferns, and one palm. Some true mangroves, like the epiphytes of *Amyema*, do not grow directly in the soil but instead grow on mangrove trees.

In this research, the classification of true mangroves followed the guidelines of Giesen et al. (2007) and the specific description by Barlow (1992), to ensure that some true mangroves, like the epiphytes of *Amyema*, were included as they can only be found exclusively in mangroves communities. However, true mangroves commonly found in previous surveys (Kusmana et al. 1997; Pribadi 1998; Yudha et al. 2021) were excluded. Similarly, mangrove-associated species commonly observed in terrestrial forests were not within the scope of this research. The morphological characteristics of the species were determined following the criteria set by Tomlinson (1986) and Giesen et al. (2007).

Result and Discussion

The research findings revealed the discovery of two previously unknown mangrove species of Bintuni Bay. These species are *Amyema mackayensis* (A. *mackayensis*) (Blakely) Danser from the Loranthaceae family, and *Brownlowia argentata* Kurz from the Malvaceae family. Interestingly, despite regular flora surveys in the southern part of the bay, these two species had yet to be previously documented. Previous research mainly focused on the production zone or interior zonation, dominated by Rhizophoraceae species (Yudha et al. 2022). In contrast, A. *mackayensis* and B. *argentata* were discovered in the ecotone area in the southern and western parts of the mangroves – areas that were rarely targeted for flora surveys (Figure 1). Both species were categorized as Least Concern (LC) according to the IUCN Red List of Threatened Species (IUCN 2022) and were not listed as protected species in the Government regulation (MoEF RI 2018).

The hydrogeomorphic setting of the mangrove forest in Bintuni Bay was classified as a tidal estuarine, which receives a significant supply of nutrient-rich sediment from the surrounding bay (Sasmito et al. 2020). Research showed that the accretion rate in young secondary forests within the interior zone and the primary forest can reach 8±7 and 3±3 mm per year, respectively (Murdiyarso et al. 2021). Over the decades, sediment accumulation led to the development of distinct zones with specific species characteristics (Noor et al. 1999). Species from the *Rhizophoraceae* family have become dominant in the interior zone, the largest in Bintuni Bay. Previous research on flora focused primarily on the interior zone (Kusmana et al. 1997; Pribadi 1998; Yudha et al. 2021, 2022). Consequently, A. *mackayensis* and B. *argentata*, located in the transitional zone (ecotone area) between mangroves and terrestrial forests, remain relatively unexplored.

In mainland New Guinea, A. *mackayensis* was previously only known in the southern regions. The species was initially documented from a single collection of Van Royen 4926 (L; CANB) by Van Royen in 1954 near Merauke Regency, Indonesia. At that time, the species was identified as a new subspecies, A. *mackayensis* subsp. cycnei-sinus (Blakely) Barlow. This information was documented in various publications, including those by Barlow in 1966, 1974 and Henty in 1981. Interestingly, these subspecies were not referenced in a later publication by the authors (Barlow 1992; see Govaerts 2003), indicating that the subspecies had been submerged.

This research revealed the presence of A. *mackayensis* in Bintuni Bay, approximately 1,033 km further north of Merauke. This finding expanded the known geographical range of the species to the northern part of Indonesian New Guinea. Notably, A. *mackayensis* was not observed in the northern part of the mainland, indicating a potential link between the species' biogeography and the geological history of

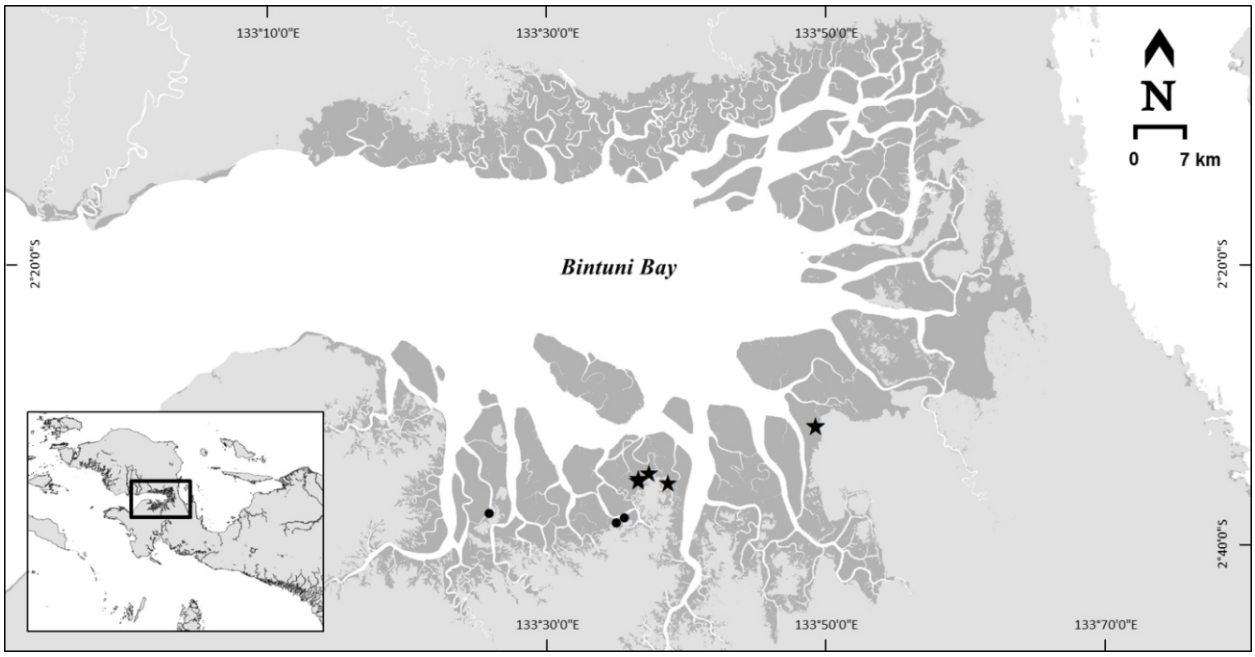

Figure 1. Distribution of *A. mackayensis* (dot) and *B. argentata* (star) as new records of true mangroves in Bintuni Bay, West Papua, Indonesia. Dark grey represents mangroves ecosystems and a small portion of other wetlands. Lighter grey represents dry lands. The ecotone area is a transitional zonation between wetlands and dry lands.

mainland New Guinea (see Box 1). In particular, the study highlights a geological connection between southern mainland New Guinea and northern mainland Australia (see Pigram & Panggabean 1984; Pigram & Davis 1987).

A. *mackayensis* was a true mangrove epiphyte species that was known to be exclusively parasitic on Avicennia, Camptostemon, Ceriops, Excoecaria, Lumnitzera, Rhizophora, and Sonneratia (Giesen et al. 2007). This species was uniquely able to accumulate excess salt in its leaves to reduce overall salinity stress (Moss & Kendall 2016). This salt exclusion mechanism was a distinctive characteristic of true mangroves (Tomlinson 1986, 2016). In the study area, the species was found in a pure mangrove stand adjacent to the ecotone area, where it grows epiphytically on R. *mucronata* and is present in three spots. The first two spots (133°35'0.002"E 2°38'24.756"S and 133°35'34.886"E 2°38'2.848"S) were situated along the Mumusi River in the southern part of the FME, approximately 1,200 m apart. The third spot was located southwest of the FME (133°25'54.985"E 2°37'45.015"S) within the mangroves that serve as a buffer zone for the Ubuara River (Figure 1).

B. *argentata* was a widely distributed species found from mainland Southeast Asia to the Solomon Islands (see Box 2), which had been documented by Kostermans (1961), Tomlinson (1986), and Ashton (1988). In the research areas, however, the species was not observed in Bintuni Bay despite its prevalence in mainland New Guinea. During the research, B. *argentata* was frequently spotted in the ecotone area adjacent to terrestrial forests, with 18 individuals observed in six distinct locations. Four of these spots (133°36'35.135"E 2°35'21.886"S, 133°36'36.609"E 2°35'13.408"S, 133°37'21.397"E 2°34'50.185"S, 133°38'43.968"E 2°35'32.023"S) were situated in the ecotone areas, while the remaining two (133°49'17.996"E 2°31'28.733"S, 133°49'18.18"E 2°31'25.784"S) were within mangrove stands (Figure 1).

The findings indicated that the ecotone area became a significant transitional zone in Bintuni Bay, as indicated by the presence of A. *mackayensis* and B. *argentata*. These two species were not encountered in the interior or production zones, underscoring the need for appropriate conservation measures to safeguard their natural habitat. In this study, two additional species were described, bringing the total number of identified true mangroves in the southern part of Bintuni Bay to 30, belonging to 12 families (Table 1). However, extensive research on the northern and eastern parts of the bay should also be conducted to provide a complete list of true mangroves in Bintuni Bay.

Table 1. True mangroves of Bintuni Bay, West Papua, Indonesia.

No.	Family	Species	References
1	Acanthaceae	*Acanthus ebracteatus* Vahl	3
2	Acanthaceae	*Acanthus ilicifolius* L.	2, 3
3	Acanthaceae	*Avicennia alba* Bl.	1, 2, 3
4	Acanthaceae	*Avicennia marina* (Forsk.) Vierh.	1, 2, 3
5	Acanthaceae	*Avicennia officinalis* L.	1, 2, 3
6	Arecaceae	*Nypa fruticans* Wurmb.	2, 3
7	Combretaceae	*Lumnitzera littorea* (Jack) Voigt	2, 3
8	Combretaceae	*Lumnitzera racemosa* Willd. var. racemosa	3
9	Euphorbiaceae	*Excoecaria agallocha* L.	2
10	Loranthaceae	*A. mackayensis* (Blakely) Danser	4
11	Malvaceae	*B. argentata* Kurz	4
12	Malvaceae	*Heritiera littoralis* Dryand. Ex W.Ait.	2, 3
13	Meliaceae	*Xylocarpus granatum* Koen.	1, 3
14	Meliaceae	*Xylocarpus moluccensis* Lamk Roem.	1, 3
15	Meliaceae	*Xylocarpus mekongensis* Pierre	2
16	Myrsinaceae	*Aegiceras corniculatum* (L.) Blanco	2, 3
17	Pteridaceae	*Acrostichum aureum* Linn.	2, 3
18	Pteridaceae	*Acrostichum speciosum* Willd.	3
19	Rhizophoraceae	*Bruguiera cylindrica* (L.) Bl.	3
20	Rhizophoraceae	*Bruguiera gymnorhiza* (L.) Lamk.	1, 2, 3
21	Rhizophoraceae	*Bruguiera parviflora* (Roxb.) W.& A. ex Griff.	1, 2, 3
22	Rhizophoraceae	*Bruguiera sexangula* (Lour.) Poir.	1, 2, 3
23	Rhizophoraceae	*Ceriops decandra* (Griff.) Ding Hou	1, 2, 3
24	Rhizophoraceae	*Ceriops tagal* (Perr.) C.B.Rob.	1, 2, 3
25	Rhizophoraceae	*Rhizophora apiculata* Bl.	1, 2, 3
26	Rhizophoraceae	*Rhizophora mucronata* Lamk.	1, 3
27	Rhizophoraceae	*Rhizophora stylosa* Griff.	2
28	Rubiaceae	*Scyphiphora hydrophyllacea* Gaertn.	2
29	Sonneratiaceae	*Sonneratia alba* Smith	1, 3
30	Sonneratiaceae	*Sonneratia caseolaris* (L.) Engl	2, 3

References: 1=Kusmana et al. (1997); 2=Pribadi (1998); 3=Yudha et al. (2021); 4=This research.

Box 1. Taxonomy and description of *Amyema mackayensis*.

Nomenclature: *A. mackayensis* (Blakely) Danser, Bull. Jard. Bot. de Buitenzorg, ser. III, vol. XI: 233–519. 1931. (Figure 2).
Type: As *Loranthus mackayensis* Blakely.
Loranthus mackayensis Blakely, Proc. Linn. Soc. New S. Wales 47 (1922): 392; ibid. 48 (1923): 131.
Type: Australia, Queensland, Mackay, *Tryon* sn. (NSW holo.)
Loranthus cycneus-sinus Blakely, Proc. Linn. Soc. New S. Wales 47 (1922): 392; ibid. 48 (1923): 131.
Type: Australia, Western Australia, West Kimberley, Cygnet Bay, Nov. 1906. *Fitzgerald* 1705 (NSW holo., PERTH iso.).
A. mackayensis subsp. *cycnei-sinus* (Blakely) Barlow, Austral. J. Bot. 14 (1966): 472.
Type: As *L. cycneus-sinus* Blakely.
Species morphology. This plant species was classified as an epiphytic parasite, featuring a smooth stem and multiple branches. The nodes where the branches intersect were larger, and the flowers tended to cluster in pairs, although they could sometimes be solitary in the leaf axils. The flower stalks tended to curve, and the calyx was funnel-shaped. The trumpet-shaped corolla varies in color, ranging from green to yellow and red. The anthers were approximately 1.5 mm in size, and the fruit was ellipsoid in shape, crowned with a calyx. The leaves were arranged oppositely, commonly displaying an obovate shape, and the stalk length was approximately 5 mm (Figure 2).
Distribution: Northern mainland Australia and the southern part of mainland New Guinea, both the Papua Province, Indonesia, and the Western Province, Papua New Guinea.
Ecology: True epiphytic species found in mangroves and exclusively parasitic, usually on the genera *Avicennia*, *Camptostemon*, *Ceriops*, *Excoecaria*, *Lumnitzera*, *Rhizophora* and *Sonneratia* (Barlow and Wiens 1977, Barlow 1992). In Bintuni Bay, *A. mackayensis* lived as an epiphyte on *R. mucronata* (Fig. 2D).
Notes: The presence of *A. mackayensis* in Bintuni Bay extended the distribution to the northern area of Indonesian New Guinea, further north than the previously known distribution area, which was restricted to the southernmost part of mainland New Guinea (Barlow 1992).

Figure 2. *A. mackayensis* from Bintuni Bay, West Papua, Indonesia. A. Flowers and leaves; B. Flower with red corollas; C. Flower buds; D. Habit as an epiphytic plant on *Rhizophora mucronata*. (Photos by Agus Sadam Husein, PT BUMWI).

Box 2. Taxonomy and description of *Brownlowia argentata*.

Nomenclature: *B. argentata* Kurz, J. Asiat. Soc. Beng 39(2): 67. 1870. Figure 3.
Type: As *B. lepidota*.
B. lepidota Warb., Bot. Jahrb. Syst. 18 (1-2): 200. 1893. Type: Malaysia, Malay Peninsula, Papua New Guinea, 09 Aug. 1888, Hellwig 248 (K holo.).
B. riedelii Hemsl., Rep. Voy. Challenger, Bot. 1 (3): 128. 1885. Type: Malay Archipelago, Wetter, Riedel sn. (K holo.).
Species morphology: The species was typically classified as a small tree or shrub, reaching a height of around 15 meters, with the potential to grow as tall as 20 m and a diameter of approximately 15 cm. Most branches emanate from the stem, and the bark is predominantly grey, displaying variations in surface texture, including mottling, cracking, flaking, and occasional smooth patches. The fruit was nut-like in appearance, often taking on a heart shape. The leaves were thin, distinctly ovate, and heart-shaped, featuring a glossy top surface and a brownish-green color on the abaxial surface of the leaves (Figure 3).
Distribution: Mainland Southeast Asia (Myanmar) through Malesia including Malaysia (Malay Peninsula only), Singapore, Indonesia, Papua New Guinea to Western Pacific (Solomon Islands).
Ecology: True mangrove species was commonly found in the landward margins or along brackish rivers and often trails in the water.
Notes: Although the species was widespread in New Guinea (Kostermans 1961; Tomlinson 1986; Ashton 1988), no reports of it were found from Bintuni Bay. B. *riedelii* (Riedel sn.) was documented in the Malay Archipelago as "Wetter". The species was previously believed to have been collected from Wetar Island in the Southwest of the Moluccas Islands. However, no evidence existed that Riedel had visited the island (Van Steenis 1950). Consequently, the accuracy of the type location and even the collector was still being determined, necessitating further research.

Figure 3. *B. argentata* from Bintuni Bay, West Papua, Indonesia. A. Fruits; B. Heart-shaped leaves with distinctive brownish-green color on the abaxial surface of the leaves; C. Stem and roots; D. Habit, showing an individual tree found in the ecotone area. (Photos by Agus Sadam Husein, PT BUMWI).

Conclusion

This research identified two previously unrecorded true mangrove species in Bintuni Bay, Indonesia. The bay was identified as a hotspot for mangrove biodiversity in Indonesia, hosting 30 true mangrove species. The ecotone area, acting as a transitional zone between mangroves and terrestrial forests, hosted valuable biodiversity, as evidenced by the discovery of the two species mentioned in this research. A. *mackayensis*, previously only known from the vicinity of Merauke in the southernmost part of the Indonesian New Guinea, was observed to extend its distribution to the Bird's Head of New Guinea's main island. Additionally, B. *argentata*, a common species on the mainland of New Guinea, was documented in Bintuni Bay for the first time. These findings highlight the importance of conducting regular species surveys and monitoring in rarely studied areas within the concession. This could lead to discovering new species and contribute to a comprehensive list of true mangrove species in Bintuni Bay. The mangroves in Bintuni Bay represented the third-largest mangroves in the world. Therefore, there is a significant potential for discovering new true mangrove records. The organization responsible for managing the area should integrate conservation and protection programs for the newly identified species discussed in this research. These programs should encompass other rare species within the bay, the overall management system, and daily operations.

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