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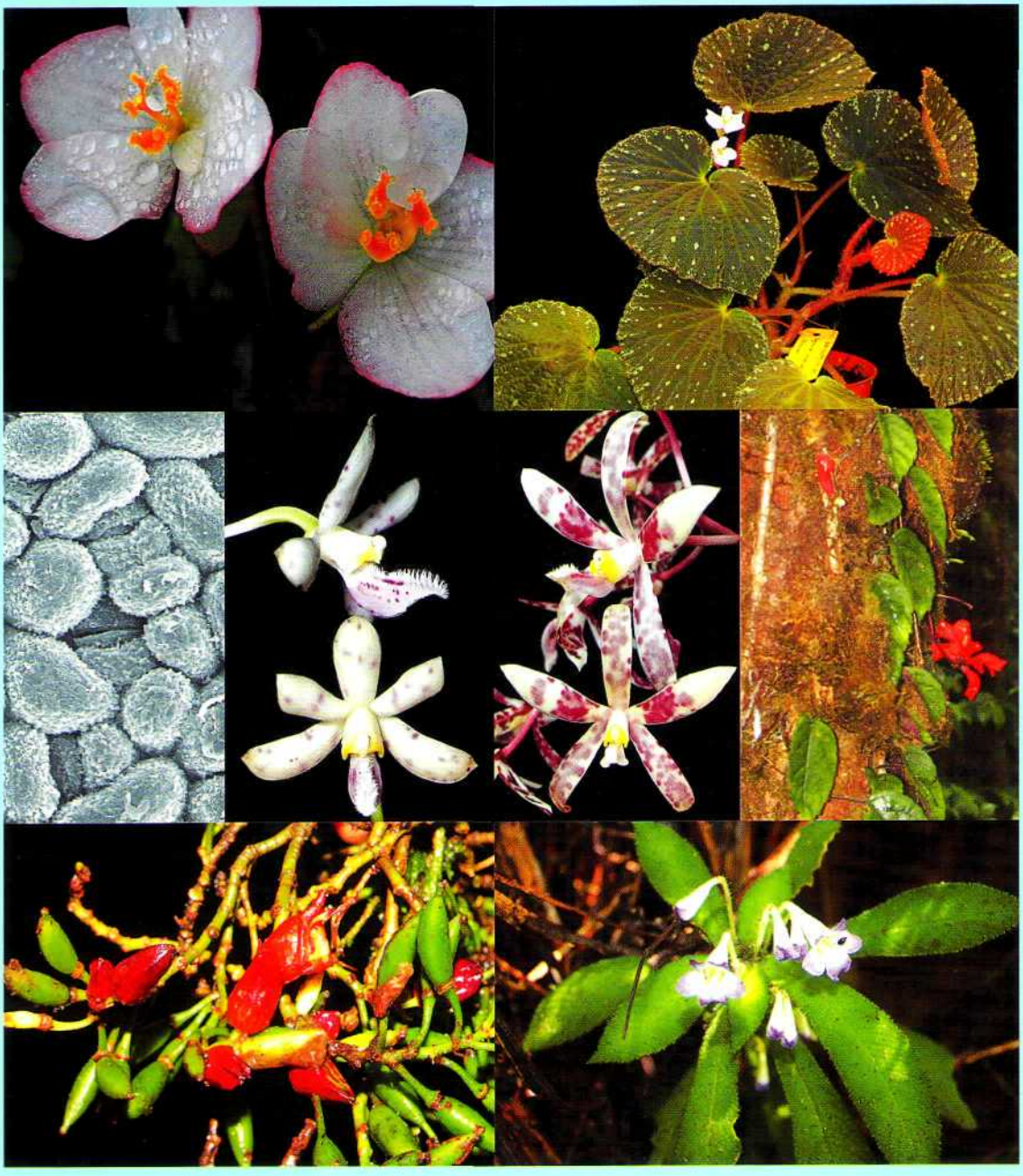

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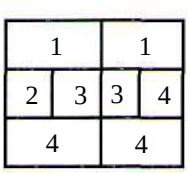

Cover images: 1. *Begonia holosericeoides* (female flower and habit) (Begoniaceae; Ardi *et al.); 2.* Abaxial cuticles of *Alseodaphne rhododendropsis* (Lauraceae; Nishida & van der Werff); *3. Dipodium puspitae, Dipodium purpureum* (Orchidaceae; O'Byrne); 4. *Agalmyla exannulata, Cyrtandra coccinea* var. *celebica, Codonoboea kjellbergii* (Gesneriaceae; Kartonegoro & Potter).

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FLORISTIC DIVERSITY AND STRUCTURAL CHARACTERISTICS OF MANGROVE FOREST OF RAJA AMPAT, WEST PAPUA, INDONESIA

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ABSTRACT
PRAWIROATMODJO, S. & KARTAWINATA, K. 2014. Floristic diversity and structural characteristics of the mangrove forests of Raja Ampat,West Papua, Indonesia. *Reinwardtia* 14(1):171 – 180. — We studied the floristic composition and structure of mangrove forests and mangrove species distribution at the Raja Ampat Regency, West Papua. We sampled the forests using (10×10 m) quadrats to record trees and saplings laid out contiguously along 9 transects of 60 – 450 m long, stretching perpendicularly from the coastlines or riverbanks to the landward borders. Seedlings were sampled using a 1×1 m subplot nested in each quadrat. The transects were established on the islands of Batanta (6), Salawati (2) and Waigeo (1). Within quadrats and transects we recorded 17 mangrove species of trees with density of 768 stems/ha and basal area of 37.82 m^2/ha and tree height of 10 – 30 m. Two species possessed the highest importance value (IV) , frequency, density and basal area *i.e. Rhizophora apiculata* (IV = 168.06%) and *Bruguiera gymnorrhiza* (IV = 67.18%). They also showed the highest similarity in their distribution, indicating highest degree of association. The mangrove at Raja Ampat may, therefore, be designated as the *Rhizophora apiculata – Bruguiera gymnorrhiza* association. Other species with highest degree of distributional similarities but with low densities, basal areas and importance values were *Barringtonia racemosa, Excoecaria agallocha, Hibiscus tiliaceus, Inocarpus fagifera, Lumnitzera littorea* and *Sterculia shillinglawii,* of which four of them are not true mangrove species, usually growing on less saline and more solid soils. The floristic composition of the transects in the three islands showed relatively high similarities of about 70% and at higher similarities the transects in Batanta Island formed four groups, Salawati Island two groups and Waigeo Island one group. The Bray-Curtis polar ordination resulted in four groups of transects, which were related to the habitat conditions and the length of the transects. Species diversity in the islands was very low, where the Shannon diversity index ranged from 0.19 to 0.64 giving the average of 0.42. *Rhizophora apiculata* and *Bruguiera gymnorrhiza* were gregenerating well and in the future they will remain dominant. The mangrove forests of the Raja Ampat Islands by any means should be maintained as green belts and protected from all kinds of destruction and should be made into conservation areas in order to sustain its ability to provide ecological services and non-destructive economic benefits.

Key words: *Rhizophora apiculata – Bruguiera gymnorrhiza* association, mangrove, Raja Ampat Islands, West Papua.

ABSTRAK
PRAWIROATMODJO, S. & KARTAWINATA, K. 2014. Diversitas floristik dan karakteristik struktur hutan mangrove di Raja Ampat, Papua Barat, Indonesia. *Reinwardtia* 14(1):171 – 180. — Penelitian struktur dan komposisi tumbuhan mangrove serta distribusi jenis mangrove telah dibuat di Kabupaten Raja Ampat, Papua Barat. Hutan dicuplik dengan sembilan transek dengan panjang 60 – 450 m yang diletakkan tegak lurus garis pantai atau tepi sungai hingga mencapai batas daratan. Setiap transek dibagi menjadi anak petak berukuran 10×10 m yang diletakkan menerus untuk merekam pohon dan belta. Semai dicuplik dengan anak petak berukuran 1×1 m yang diletakkan menyarang di setiap petak. Transek dibuat di Batanta (6), Salawati (2) dan Waigeo (1). Dalam transek dan petak tercatat 17 jenis pohon mangrove dengan kerapatan 768 pohon/ha dan area dasar 37.82 m2/ha serta tinggi pohon 10 – 30 m. Dua jenis yang memiliki nilai kepentingan (NK), frekuensi, kerapatan dan area dasar tertinggi adalah *Rhizophora apiculata* (NK = 168.06%) dan *Bruguiera gymnorrhiza* (NK= 67.18%). Dua jenis tersebut memiliki kesamaan sebaran, yang menunjukkan derajat assosiasi yang tinggi. Dengan nilai kepentingan dan kesamaan sebaran tersebut sebagai kriteria, mangrove di Raja Ampat dapat disebut sebagai Asosiasi *Rhizophora apiculata – Bruguiera gymnorrhiza.* Jenis lain yang memiliki kerapatan, area dasar dan nilai penting rendah adalah *Barringtonia racemosa, Excoecaria agallocha, Hibiscus tiliaceus, Inocarpus fagifera, Lumnitzera littorea* dan *Sterculia shillinglawii* dan empat di antaranya adalah bukan mangrove sejati yang biasanya tumbuh pada tanah agak padat dengan kadar garam rendah. Komposisi jenis dari transek di tiga pulau menunjukkan kesamaan yang relatif tinggi, sekitar 70%. Dengan kesamaan yang tinggi transek di Pulau Batanta membentuk empat kelompok, Pulau Salawati dua kelompok dan Pulau Waigeo satu kelompok. Ordinasi polar Bray-Curtis menghasilkan empat kelompok transek, yang terkait dengan kondisi habitat

dan panjang transek. Diversitas jenis di pulau-pulau di Raja Ampat sangat rendah, seperti ditunjukkan oleh indek diversitas Shannon yang berkisar dari 0.19 sampai 0.64 dengan nilai rata-rata 0.42. *Rhizophora apiculata* dan *Bruguiera gymnorrhiza* mempunyai regenerasi yang baik dan di masa depan mereka akan tetap dominan. Dengan segala upaya hutan mangrove Raja Ampat hendaknya tetap dipertahankan sebagai jalur hijau mangrove dan sebagai areal konservasi untuk mempertahankan kemampuannya sebagai penyedia jasa ekologi dan manfaat ekonomi tidak destruktif.

Kata kunci: Asosiasi *Rhizophora apiculata Bruguiera gymnorrhiza*, mangrove, Kepulauan Raja Ampat, Papua Barat.

INTRODUCTION

Indonesia as an *archipelago state,* consisting of more than 17.508 islands with a coastline of 81.000 km long (Soegiarto, 1984), has a very extensive mangrove forests. The mangroves provide live supports for a diversity of marine biota, such as providing breeding sites, nursery grounds, feeding sites and protection. Therefore, mangrove ecosystems have received a great deal of scientific attention.

The most extensive mangrove forests in Indonesia are found in Papua, covering a total area of 1.634.003 ha (hectares) or 50.4 % of the total mangroves of Indonesia (Saputro *et al.,* 2009). In the Raja Ampat Regency, they cover a total area of 28.050 ha (Saputro *et al.,* 2009), occurring on the Waigeo Island (6.843 ha), Batanta Island (785 ha), Kofiau Island (279 ha), Misool Island (8.093 ha) and the Salawati Island (4.258 ha) (Anynomous, 2006). The mangrove forests that have been designated as conservation areas in Papua cover only 148.000 ha.

The mangroves throughout the country, including in Raja Ampat, are continually threathened by deforestation and clearance, particularly the conversion to schrimp and fish ponds. Therefore, conserving mangroves is a must, as sanctioned by several government decrees, The Presidential Decree No. 32/1990, for instance, requires local governments to establish Mangrove Green Belt. In several national parks, undisturbed mangroves along with other undisturbed ecosystems constitute the core zones.

Elsewhere the floristic composition and structure of mangrove forests have been well studied and reported in numerous publications and proceedings of workshop and symposia (*e.g.* Soemodihardjo *et al.,* 1991). An accunt of the mangrove forests of Papua, treated as part of the entire island of New Guinea, is briefly presented by Alongi (2007). Various studies and reviews on Raja Ampat (McKenna *et al.,* 2002; Palomares & Heymans 2006; Webb, 2005) barely mentioned mangrove forests. We, therefore, know very little about the species composition and structure of mangrove forests on the islands in the Raja Ampat Regency, and so far only two records are available. Anynomus (2006) registered 25 true mangrove species and 27 mangrove-associated species in Raja Ampat. Takeuchi (2003) did a community-level reconnaisance on the mangrove along the banks of the Gam and Kasin rivers and described the mangrove in Raja Ampat as being sparse and poor in species compared to the New Guinea mainland. In the present study, therefore, our investigation focus on floristic and structural aspects, which are important for establishing conservation areas and subsequent management and monitoring, in particular in view of the threat from increasing ecotourism development and conversion for economic and physical development in the regency.

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STUDY SITE AND METHODS

The Raja Ampat Islands (Fig. 1) are geographically located on 2°25'N - 4°25'S and on 130° - 132°55'E, comprising four main islands, *i.e.* Batanta (Batanta Island), Misool (Misool Island), Salawati (Salawati Island) and Waigeo (Waigeo Island). The area has a seasonal climate, showing a dry season from October to March with monthly rainfall of 170 mm and a wet season from April to Setember with monthly rainfall of 270 mm (McKenna *et al.,* 2002). The ecosystems around the islands consist of coral reefs, mangroves and sea-grass beds, which experience maximum daily tide fluctuations of 1.8 m with the average fluctuation of 0.9-1.3 m (McKenna *et al.,* 2002).

Sampling of mangrove forests using transect methods were undertaken at Yenana in Selat Sagawin district on Batanta, at Samate in Salawati Utara district on Salawati and at Kalitoko on Waigeo (Fig. 1). We established nine transects, stretching perpendicularly from the coastlines or riverbanks to the inland edges of the forests bordering with the dryland. Each transect was 10 m wide and its length and geographic position were as follows:

(1) At Yenanas on Batanta, six transects were established and the overall distance between Transect 1 and Transect 6 was 17,500 m.

Transect 1 was 60 m long, located in a forest bordering an open sea at $0^0$51'0.6"S and $130^0$5'43.4"E; Transect 2 was 70 m long, located in a forest along a river at 0^0 50' 58.7"S and $130^0$51'42.9"E, Transect 3 was 180 m long, located in a forest on an estuary at $0^0$50'58.7"S and $130^0$51'42.9"E, Transect 4 was 110 m long, located in a forest along a river at $0^0$51'9.2"S and $130^0$51'11.0"E, Transect 5 was 200 m long, located in a forest bordering an open sea at 0^0 50'9.6"S and $130^0$53'12.4"E and Transect 6 was 200 m long, located in a forest bordering an open sea at $0^0$50'20.3"S and $130^0$53'3.4"E.

(2) At Samate on Salawati, two transects, with the length of 200 m each, were established in a forest on an estuary at $0^0$59'25.4"S and $131^0$4'7.1"E and $0^0$58'18.4"S and $131^0$4' 52.7" E.

(3) At Kalitoko on Waigeo one transect with the length of 450 m was established in a forest located on a bay at 0^o14'19.3" S & 130^o48'25.6" E.

Each transect was divided into (10×10 m) plots to record trees with diameters at breast height (DBH) of ≥ 10 cm and saplings with DBH of 2-9.9 cm and a (1×1 m) subplot was nested within each plot to record seedlings with DBH of < 2 cm. If stilt roots were present the diameters were measured at 10 cm above stilt roots. The height of trees and saplings were estimated. The Importance Value of each species at tree and sapling stages was calculated by summing up the Relative Density (RD), Relative Basal Area (RBA) and Relative Frequency (RF). Basal area was used to measure the dominance. Biodiversity professional Version 2.0 (McAleece *et al*., 1997) was used for Bray-Curtis Cluster Analysis with Sorensen similarity to construct grouping of transects and species and to calculate Shannon diversity index. Bray-Curtis polar ordination of transects was performed using PC-ORD (Peck, 2010). All individuals within the plots and subplots were identified to species. Species present outside the transects were also listed so as to obtain a general information on mangrove flora of the study sites but they were not included in the transect data analysis. Voucher specimens were collected and identified at the Herbarium Bogoriense, Research Center for Biology, Indonesian Institute of Sciences at Cibinong, Bogor. The water depths on the riverside, seaside and the inland ends of each transect was measured with a measuring stake. The percentage of the canopy gaps along each transect was estimated.

Fig. 1. The study sites on Waigeo, Batanta, and Salawati in the Raja Ampat Regency (Kabupaten), West Papua, Indonesia

RESULTS AND DISCUSSION

Floristic composition

Mangrove forests on the Raja Ampat Islands, occuring along the coastal areas, rivers and estuaries extending to the inland with variable thickness, were mostly still in good conditions. Table 1 shows the results of floristic and structural analyses within the transects on Batanta, Salawati and Waigeo, where we recorded 17 species of 12 families, of which 11 were true mangrove species. Six true mangrove species occurred in the three islands, six species (mostly non mangrove species) were found on Waigeo, two species were present in Batanta and Waigeo, two species were recorded only in Salawati and one species was found only in Batanta. The spesies have been registered in the IUCN Redlist of Threatened Species Version 2013.2 as least concerned with decreasing population (www.iucnredlist.org, accessed on 23 December 2013). Species present within and outside the transects are listed in Appendix 1 to give a general idea of the flora of the study sites.

The mangrove forests on the three islands in Raja Ampat were characterized by species no 1-6 in Table 1, with IV of 3.21–168.06%, BA of 0.08-24.71 m^2 and D of 4-463 trees/ha. The similarity indices for distribution of species are presented in Fig. 2. *Rhizophora apiculata* and *Bruguiera gymnorrhiza* had the highest degree of similarity of distribution in the quadrats within the transects (similarity of 90%). Except *for Heritiera littoralis,*

Fig. 2. Dendrogram (based on tree density) of tree species distribution in transects on Batanta, Salawati and Waigeo in the Raja Ampat Islands using BioDiversityProfessional Version 2 (McAleece *et al.* 1997).

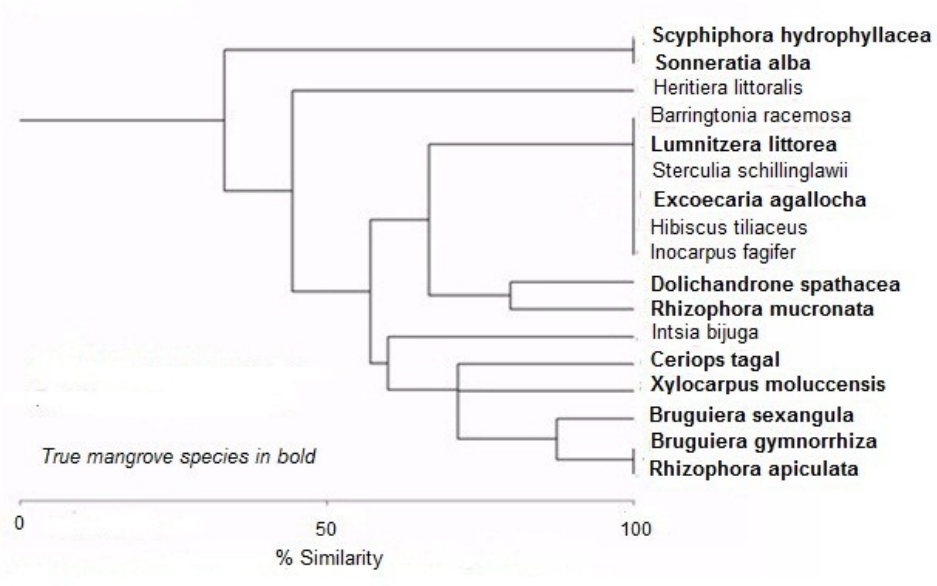

Table 1. Area (BA=m^2/ha) and Importance Value (IV=%) of true mangrove (TM) and non-mangrove (NM) tree species in the transects in the mangrove forests on Batanta Density (D=trees/ha), Basal, Salawati and Waigeo. The spesies have been registered in the IUCN Redlist of Threatened Species. Version 2013.2 as least concerned with decreasing population (www.iucnredlist.org. Accessed on 23 December 2013).

No	Species	Status	Batanta			Salawati			Waigeo		
			D	BA	IV	D	BA	IV	D	BA	IV
1	*Rhizophora apiculata*	TM	623	32.14	172.02	278	25.64	175.71	304	10.3 6	146.70
2	*Bruguiera gymnorrhiza*	TM	205	13.20	74.76	25	5.50	94.09	27	0.50	13.69
3	*Bruguiera sexangula*	TM	70	2.72	26.67	218	0.45	9.21	113	2.73	54.98
4	*Xylocarpus moluccensis*	TM	45	1.07	14.42	8	0.02	1.82	42	1.08	30.76
5	*Rhizophora mucronata*	TM	18	0.92	4.27	13	0.55	8.15	9	0.46	6.57
6	*Ceriops tagal*	TM	5	0.09	2.46	33	0.03	1.83	4	0.12	2.68
7	*Barringtonia racemosa*	NM	-	-	-		-	-	2	0.02	1.74
8	*Excoecaria agallocha*	TM	-	-	-	-	-	-	2	0.15	2.43
9	*Hibiscus tiliaceus*	NM	-	-	-	-	-	-	7	0.12	3.09
10	*Inocarpus fagifer*	NM	-	-	-	-	-	-	11	2.02	17.81
11	*Lumnitzera littorea*	TM	-	-	-		-	-	2	0.03	1.79
12	*Sterculia shillinglawii*	NM	-	-	-	-	-	-	2	0.08	2.08
13	*Dolichandrone spathacea*	TM	2	0.07	0.97	-	-	-	22	0.92	13.93
14	*Intsia bijuga*	NM	6	0.17	2.14	-	-	-	2	0.02	1.77
15	*Heritiera littoralis*	NM	2	0.44	2.29						
16	*Sonneratia alba*	TM				8	0.54	5.56			
17	*Scyphiphora hydrophyllacea*	TM	-	-	-	5	0.05	3.64	-	-	-
	Sum		977	50.81	300	588	32.79	300	551	18.6	300
	Number of species		9			9			14		
	Number of transects and area sampled (m2)		6 (8200)			2 (4000)			1 (4500)		

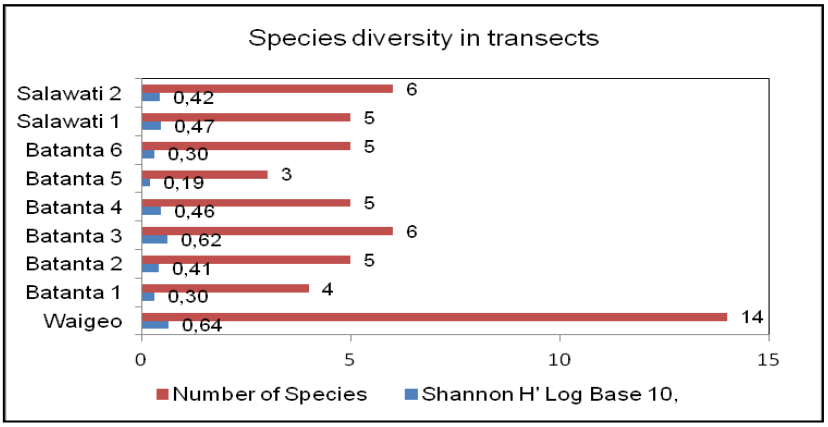

Fig. 3. Number of species and Shannon diversity indices in transects at Batanta, Salawati and Waigeo. Shannon diversity indices were calculated using BioDiversity Professional Version 2 (McAleece *et al.,* 1997).

Soneratia alba and *Scyphiphora hydrophyllacea*, other species had relatively high similarities of distribution (similarity of > 50%) *Rhizophora apiculata* was also a species with highest Importance Value (168.06%), followed by *Bruguiera gymnorhhyza* (67.18%). Based on the similarity of distribution and high importance values, the two species could be used as character species for naming mangrove forest at Raja Ampat as *Rhizophora apiculata–Bruguiera gymnorrhiza* association. It slightly differed from the finding of Takeuchi (2007) who did a community-level reconnaisance on the mangrove along the banks of the Gam and Kasin rivers, and named the forest as the *Bruguiera gymnorrhiza–Rhizophora mucronata* association. The areas were not covered in the present study. As a whole the mangrove in Raja Ampat had a low species diversity as indicated by the Shannon diversity indices that range from 0.19 at Batanta transect 5 to 0.64 at Waigeo transect (Fig. 3), giving the average of 0.42.

The dendrogram of species composition based on tree density among transects (Fig. 4) shows a relatively high floristic similarities (>65%). At 69% and higher similarities, transects from groups 3 on Batanta Island, 2 on Salawati Island and 1 on Waigeo. Clustering seems attributed to differing number of species in the transect as well as due to the presence of certain species, whose presence were restricted to each transect (Table 1). The occurrence of *Lumnitzera littorea, Excoecaria agallocha, Inocarpus fagifer, Hibiscus tiliaceus, Sterculia shillinglawii* and *Baringtonia racemosa* were restricted to Waigeo Island, *Sonneratia alba* and *Scyphiphora hydrophyllacea* to Salawati Island and *Heritiera littoralis* to Batanta Island. These species show also separate clustering in the dendrogram (Fig. 2).

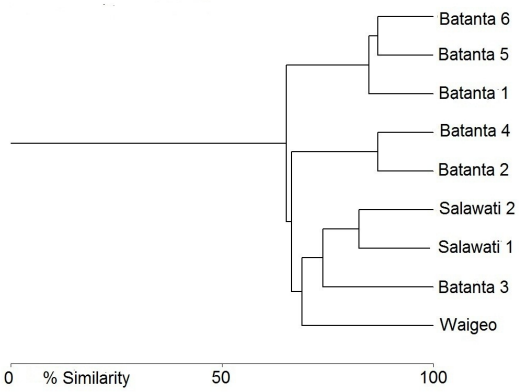

Fig. 4. Dendrogram of floristic similarities based on tree density among transects in Batanta, Salawati and Waigeo, using BioDiversit Professional Version 2 (McAleece *et al.,* 1997)

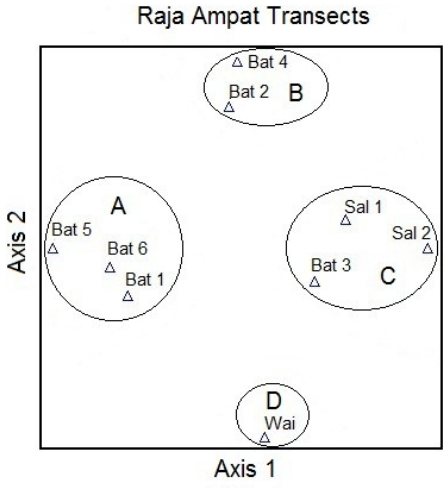

Fig. 5. Bray-Curtis polar Ordination using PC-ORD (Peck 2010) showing the grouping (A–D) of the Batanta transects (Bat 1 – Bat 6), Salawati transects (Sal 1 and Sal 2)) and Waigeo trasnsect (Wai).

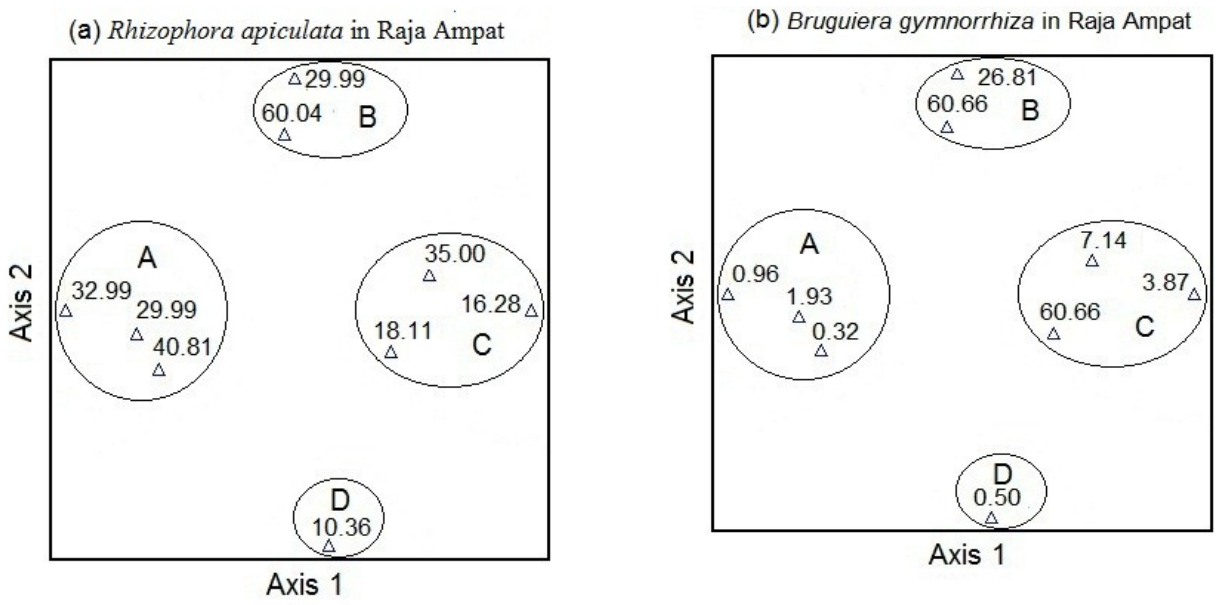

Fig. 6. Basal Area (m^2/ha) of (a) *Rhizophora apiculata* and (b) *Bruguiera gymnorrhiza* in transects of Groups A, B, C, and D. plotted over the the ordination diagram

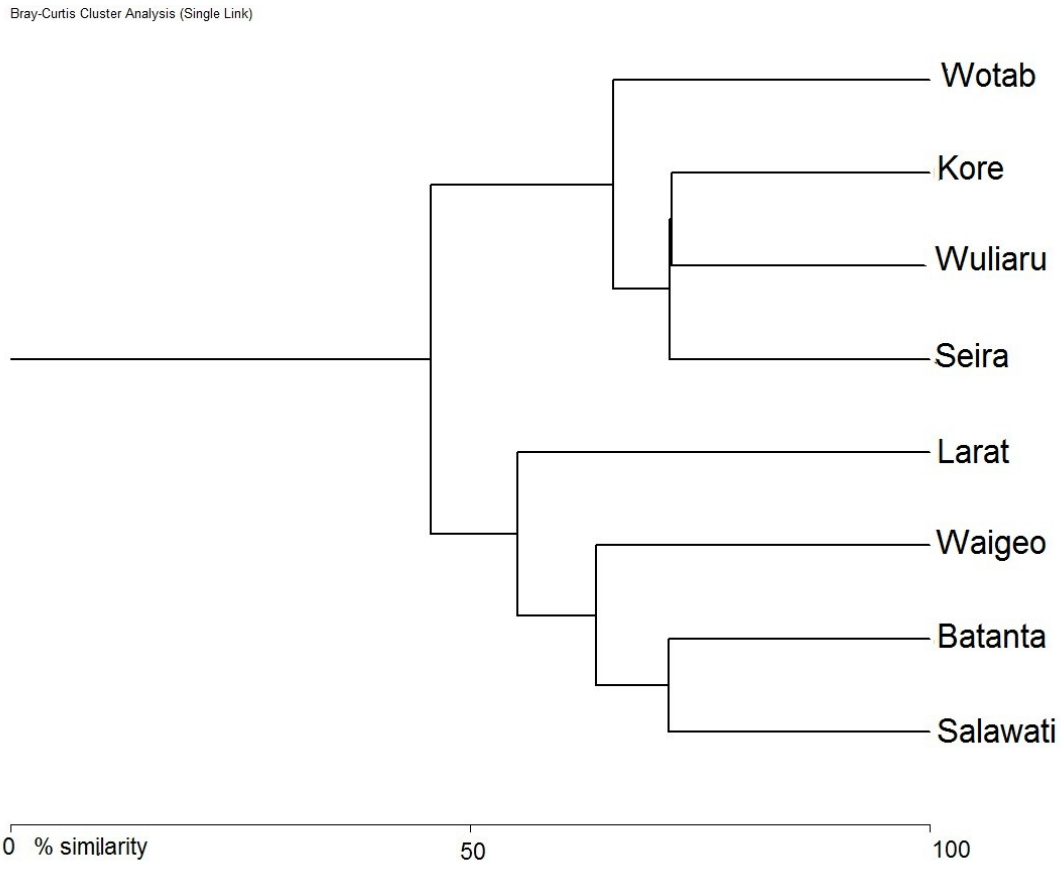

Fig. 7. Comparison of floristic composition of mangrove forests in the Raja Ampat Islands Batanta, Salawati and Waigeo) with those on small islands in Southeast Maluku (Larat, Seira, Wotab, Wuliaru and Kore). (Data extracted from Pramudji, 1987; Puluhamuny, 2003; Suhardjono & Hapid, 2011) using BiodivPro (McAleece *et al.,* 1997).

The Bray-Curtis polar ordination (Fig. 5) resulted in similar grouping of transects as that of the cluster analysis shown in Fig. 4 above. The groups are related to the habitat conditions and the length of the transects. Group A consisted of transects with average length of 153 m, whose outer ends were located on the forests bordering with the open sea. The water depths at the seaside ends of the transects were 25-35 cm and the inland ends were 5-10 cm. The average canopy gaps were about 60%. In Group B the average transect length was 90 m, with the outer ends located on the riverbanks. The water depths on the riverbank sides of the transects were 20-30 cm and at the inland side were 5-10 cm. The average canopy gaps were about 30%. In Group C the average transect length was 193 m and located at the estuaries. The water depths at the riverbank sides were 10-20 cm and at the inland sides were 5 cm. The average canopy gaps were about 20%. Group D consists of only one transect of 450 m long. located in the forest at the bay. The water depth at the bay side of the transect was 70 cm and at the inland side was 5 cm. The average canopy gaps were about 10%. *Rhizophora apiculata* was consistently dominant in most transects and all groups (Fig. 6a), while *Bruguiera gymnorrhiza* was co-dominant in transects 2 and 4 of the Group 2 and dominant in transect 3 of the Group C (Fig. 6b).

Fig. 7 shows the comparison of floristic composition of mangroves in the Raja Ampat Islands (Batanta Island, Salawati and Waigeo) and small islands in Southeast Maluku (Larat, Seira, Wotab, Wuliaru and Kore) with Bray and Curtis cluster analysis using Sorensen similarity formula and making use of denssity data of transects with lengths of 190-390 m available in Pramudji (1987), Puluhamuny (2003) and Suhardjono & Hapid (2011). The floristic composision differered a great deal as indicated by similarities among islands which varied between 25 and 75% despite limitted number of species occurring in mangroves. The mangrove of the Raja Ampat Islands floristically very close to that in Larat Island, having similarities of 55.16%. Within the restricted number of species in the mangrove environment, each island had apparently its own set of floristic combination, that characterized the community. The mangrove forests have been traditionally used by local communities as a source of family income, through harvest of fish, prawns, plants for medicinal uses, timber and firewood. Toteng (2004) recorded 12 mangrove species used by the local communities in Waren II village, Waropen Regency.

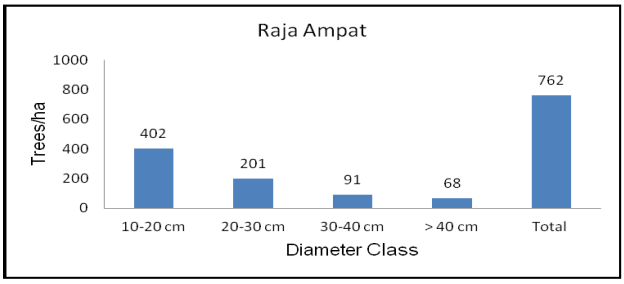

Fig. 8. Diameter class distribution and the density of trees in the Raja Ampat Islands as calculated from data at Batanta, Salawati and Waigeo .

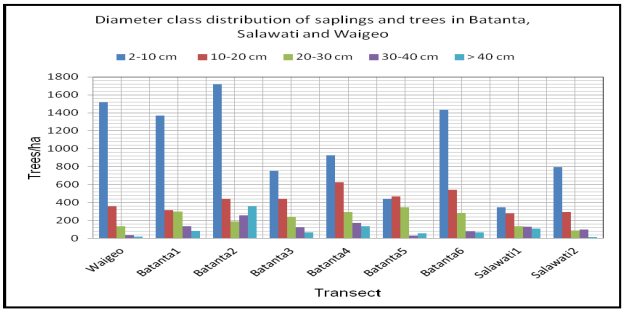

Fig. 9. Diameter class distribution of saplings and trees in transects on Batanta, Salawati and Waigeo in the Raja Ampat Islands, West Papua.

Structure

We described the forest structure in terms of horizontal spatial distribution, diameter class distribution and vertical height distribution. All trees recorded in the quadrats were classified according to diameter classes (Fig. 8). It revealed that the majority of the trees (52.76%) were in the 10-20 cm diameter class and the diameters of the rests were distributed in the the diameters > 20 cm. It was true also for each island (Fig. 9), where the trees of this diameter class were dominant but varied in number from 280 trees/ha in Salawati 1 to 627 trees/ha in Batanta 4. Fig. 9 shows also that plants at the sapling stage were very abundant in each transect, ranging in number from 280 trees/ha in Salawati 1 to 1714 trees/ha in Batanta 2. Trees with diameters >40 cm were rare, where the highest number was recorded in Batanta 2 (357 trees/ha) and the lowest was in Salawati 2 (15 trees/ha). *Rhizophora apiculata* and *Bruguiera gymnorrhiza* dominated the largest diameters.

Vertically the forests in the transects studied were dominated by trees with heights of 5-15 m, totalling 1254 trees/ha (69.67%) (Fig. 10). Trees with the heights of 5-10 m and >15 m were equally abundant, amounting to 561 trees/ha (31.03%) and 546 trees/ha (30.20%), respectively, while the understory at height of 2-5 m was very poor totaling only 8 trees/ha (0.44%). Thus the forests were solidly occupied by trees with height of 5-15 m and diameters of 10-30 cm. The species with height >

15 m were *Bruguiera gymnorrhiza, B. sexangula, Ceriops tagal, Dolichandrone spathacea, Excoecaria agallocha, Heritiera littoralis, Inocarpus fagifer, Intsia bijuga, Lumnitzera littorea, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba* and *Xylocarpus moluccensis*. The tallest trees with height > 40 m recorded in the transecs were *Bruguiera gymnorrhiza, B. sexangula, Heritiera littoralis, Inocarpus fagifer, Rhizophora apiculata* and *Sonneratia alba*. The dominant species in each height class, however, was *Rhizophora apiculata* with *Bruguiera gymnorrhiza* as the co-dominant.

Regeneration

We investigated the tree seedling community in relation to regeneration. Population structure, dominance and distribution of tree species and the number of individuals in each species at tree, sapling and seedling stages are indicators of the ability of a forest to regenerate itself and to maintain its survival, stability and sustainability. A stable forest ecosystem would have optimum density and the individuals of each species are normally well spread along diameter classes. Table 2 presents the number of individuals/ha in seedling, sapling and tree stages of five main species. It is clear that the two main species, *Rhizophora apiculata* and *Bruguiera gymnorrhiza* had very good regeneration and the regeneration of, *Bruguiera sexangula* and *Rhizophora mucronata* was poorer. *Xylocarpus moluccensis* was not regenerating at all as indicated by the absence of its seedlings. We noted that the non-mangrove species were not regenerating in the true mangrove habitats, although seedlings and saplings may be found in the transition area between swamp and dryland. The above account implies that in the future *Rhizophora apiculata* and *Bruguiera gymnorrhiza* will remain dominant in the mangrove forests of the Raja Ampat Islands, unless the forests experience severe disturbance, where pioneer and secondary forest species will initiate successions. In the present community pioneers and secondary species occurred insignificantly in gaps within the forests and at the periphery of the mangrove communities.

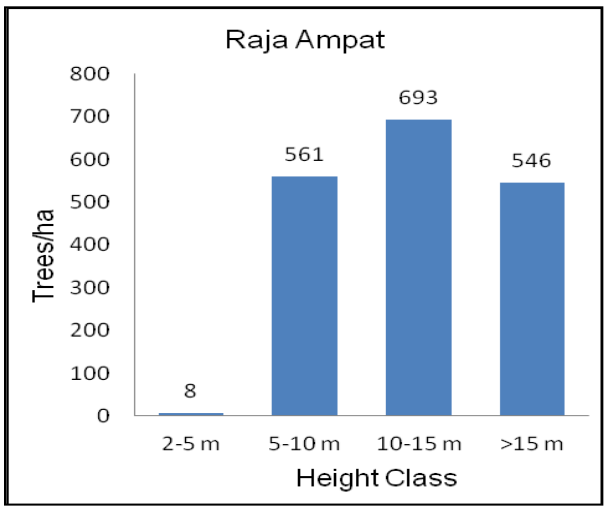

Fig. 10. Height class distribution of trees and saplings in Raja Ampat Islands as calculated from data at Batanta, Salawati and Waigeo.

Table 2. Regeneration of five leading species in transects at Batanta, Salawati and Waigeo in the Raja Ampat Islands presented as density (number of individuals/ ha) in each diameter classes.

No.	Species	Diameter Class					
		<2 cm	2-10 cm	10-20 cm	20-30 cm	30-40 cm	> 40 cm
1	*Rhizophora apiculata*	133,293	507	167	106	62	43
2	*Bruguiera gymnorrhiza*	53,832	161	91	36	11	16
3	*Bruguiera sexangula*	16,108	354	48	14	4	3
4	*Rhizophora mucronata*	2,874	898	958	419	240	-
5	*Xylocarpus moluccensis*	-	40	7	3	1	-

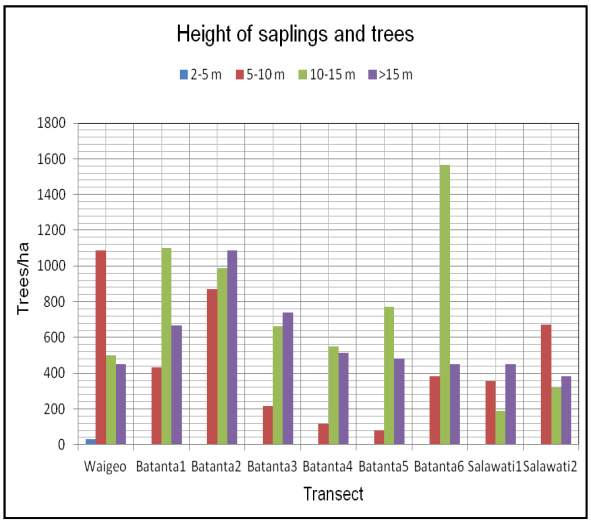

Fig. 11. Height class distribution of saplings and trees in transects at Batanta, Salawati and Waigeo in the Raja Ampat Islands

CONCLUSION

The mangrove forest at Raja Ampat is structurally dense with low species diversity. It is still in relatively good conditions with no apparent indication of having been severely disturbed and only natural disturbances might have taken place resulting in the gap formation in the canopy. So far no indication of significant number of secondary forest species have invaded the communities.

Rhizophora apiculata and *Bruguiera gymnorrhiza* jointly dominated the forest at seedling, sapling and tree stages, confirming themselves that their dynamic good regeneration ensure the species will stay in the community unless severe perturbation interferes and stimulates the successional changes to set in. The above two species were complemented by less prevalent but important species, *Bruguiera sexangula* and *Xylocarpus moluccensis.*

The mangrove forests in the Raja Ampat Islands should, by any means, be conserved, managed and maintained as the green belts, whose width should satisfy the requirements and critera that have been developed for Papua (Wartaputra, 1991). Any attempt to convert them into other uses, should be avoided. Any disturbed sites should be restored applying the principles of accelerated natural successions.

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APPENDIX 1. List of species occurring in the transects and their vicinity in the Raja Ampat Islands, West Papua.

In the transects and their vicinity in Batanta, Salawati and Waigeo of the Raja Ampat Islands, we listed 109 species, 83 genera and 52 families, of which only 27 were true mangrove species and the remainders were non halophytic species, growing generally in the transisition areas between saline mangrove swamp and terrestial dryland soils. We classified them into the following groups:

Group 1: Species present in Batanta, Salawati and Waigeo

Asclepiadaceae: *Finlaysonia obovata* Wall.; **Asteraceae:** *Melanthera biflora* (L.) Wild; **Avicenniaceae:** *Avicennia officinalis* L.; **Calophyllaceae:** *Calophyllum inophyllum* L.; **Combretaceae:** *Lumnitzera littorea* (Jack) Voigt; **Euphorbiaceae:** *Excoecaria agallocha* L.; **Fabaceae:** *Derris trifoliata* Lour.; *Pongamia pinnata* (L.) Pierre; **Flagellariaceae:** *Flagellaria indica* L.; **Goodeniaceae:** *Scaevola taccada* (Gaertn.) Roxb.; **Lecythidaceae:** *Barringtonia asiatica* (L.) Kurz; *Barringtonia racemosa* (L.) Spreng.; **Malvaceae:** *Hibiscus tiliaceus* L.; **Meliaceae:** *Xylocarpus granatum* J. Koenig; *Xylocarpus moluccensis* (Lam.) M. Roem.; **Pandanaceae:** *Pandanus tectorius* Parkinson ex Du Roi; **Rhizophoraceae:** *Bruguiera gymnorhiza* (L.) Lam.; *Bruguiera sexangula* (Lour.) Poir.; *Ceriops tagal* (Perr.) C.B.Rob.; *Rhizophora apiculata* Blume; *Rhizophora mucronata* Lam.; **Rubiaceae:** *Scyphiphora hydrophylacea* C.F.Gaertn.; **Sonneratiaceae:** *Sonneratia alba* Sm.; *Sonneratia caseolaris* (L.) Engl.; **Sterculiaceae:** *Heritiera littoralis* Aiton; **Verbenaceae:** *Clerodendrum inerme* (L.) Gaertn.

Group 2. Species present in Batanta and Waigeo

Acanthaceae: *Acanthus ebracteatus* Vahl; **Asclepiadaceae:** *Tylophora cissoides* Blume; **Bignoniaceae:** *Dolichandrone spathacea* (L.f.) Seem.; **Combretaceae:** *Terminalia catappa* L.; **Fabaceae:** *Dalbergia candenatensis* (Dennst.) Prain; *Intsia bijuga* (Colebr.) Kuntze; **Malvaceae:** *Thespesia populnea* (L.) Sol. ex Corrêa; **Pteridaceae:** *Acrostichum speciosum* (Fée) C. Presl; **Sapindaceae:** *Allophylus cobbe* (L.) Raeusch.; **Verbenaceae:** *Teijsmanniodendron hollrungii* (Warb.) Kosterm.

Group 3. Species present in Batanta and Salawati

Acanthaceae: *Acanthus ilicifolius* L.; **Aizoaceae:** *Sesuvium portulacastrum* (L.) L.; **Apocynaceae:** *Cerbera manghas* L.; **Arecaceae:** *Nypa fruticans* Wurmb; **Convolvulaceae:** *Ipomoea pes-caprae* Roth; **Fabaceae:** *Sophora tomentosa* L.; **Meliaceae:** *Xylocarpus rumphii* (Kostel.) Mabb.; **Olacaceae:** *Ximenia americana* L.; **Pandanaceae:** *Pandanus dubius* Spreng.; *Pandanus odorifer* (Forssk.) Kuntze; **Pteridaceae:** *Acrostichum aureum* L.; **Rhizophoraceae:** *Bruguiera cylindrica* (L.) Blume; *Bruguiera parviflora* (Roxb.) Wight & Arn. ex Griff.; *Rhizophora lamarckii* Montrouz.; *Rhizophora stylosa* Griff.; **Rubiaceae:** *Morinda citrifolia* L.; **Rutaceae:** *Limonia* sp.

Group 4. Species present only in Waigeo

Apocynaceae: *Alyxia floribunda* Markgr.; **Araceae:** *Rhaphidophora* sp.; **Asclepiadaceae:** *Hoya lacunosa* Blume; **Asparagaceae:** *Dracaena angustifolia* (Medik.) Roxb; **Avicenniaceae:** *Avicennia marina* subsp. *australasica* (Walp.) J.Everett; **Bombacaceae:** *Camptostemon schultzii* Mast.; **Convolvulaceae:** *Ipomoea gracilis* R. Br.; **Cyatheaceae:** *Cyathea* sp.; **Cyperaceae:** *Mapania macrocephala* (Gaudich.) K.Schum.; **Dryopteridaceae:** *Tectaria zeylanica* (Houtt.) Sledge; **Ebenaceae:** *Diospyros cauliflora* Blume; **Euphorbiaceae:** *Shirakiopsis indica* (Willd.) Esser; **Fabaceae:** *Caesalpinia bonduc* (L.) Roxb.; *Caesalpinia crista* L.; *Cynometra ramiflora* L.; *Derris elegans* Benth.; *Inocarpus fagifer* (Parkinson) Fosberg; **Hernandiaceae:** *Hernandia sonora* L.; **Loganiaceae:** *Fagraea racemosa* Jack; **Meliaceae:** *Aphanamixis polystachya* (Wall.) R.Parker; **Menispermaceae:** *Arcangelisia flava* (L.) Merr.; **Moraceae:** *Artocarpus teysmannii* Miq.; **Rhizophoraceae:** *Ceriops decandra* (Griff.) W.Theob.; **Rubiaceae:** *Hydnophytum moseleyanum* Becc.; **Sterculiaceae:** *Scaphium macropodum* (Miq.) Beumée ex K.Heyne; **Tiliaceae:** *Brownlowia argentata* Kurz; **Verbenaceae:** *Premna serratifolia* L.

Group 5. Species present only in Batanta

Borraginaceae: *Cordia dichotoma* G. Forst.; **Cannabaceae:** *Celtis philippensis* Blanco; **Celastraceae:** *Siphonodon* sp.; **Clusiaceae:** *Garcinia dulcis* (Roxb.) Kurz; **Fabaceae:** *Dendrolobium umbellatum* (L.) Benth.; *Mucuna bennettii* F. Muell.; **Lythraceae:** *Pemphis acidula* J. R. Forst.; **Moraceae:** *Ficus adenosperma* Miq.; *Ficus botryocarpa* Miq.; **Myrsinaceae:** *Ardisia elliptica* Thunb.; **Nyctaginaceae:** *Boerhavia diffusa* L.; **Orchidaceae:** *Coelogyne* sp.; *Dendrobium aloifolium* (Blume) Rchb. f.; **Piperaceae:** *Piper betle* L.; **Rubiaceae:** *Aidia racemosa* (Cav.) Tirveng.; *Guettarda speciosa* L.; **Rutaceae:** *Atalantia monophylla* D. C.; **Sapotaceae:** *Planchonella obovata* (R. Br.) Pierre; **Sonneratiaceae:** *Sonneratia ovata* Backer; **Thymelaeaceae:** *Phaleria perrottetiana* (Decne.) Fern.-Vill. ; **Tiliaceae:** *Grewia laevigata* Vahl; **Verbenaceae:** *Clerodendrum buchananii* (Roxb.) Walp.

Group 6. Species present only in Salawati

Avicenniaceae: *Avicennia marina* (Forssk.) Vierh.; **Combretaceae:** *Lumnitzera racemosa* Willd.; **Myrsinaceae:** *Aegiceras floridum* Roem. & Schult.; **Myrtaceae:** *Osbornia octodonta* F. Muell.; **Sterculiaceae:** *Heritiera globosa* Kosterm.

Group 7. Species present in Waigeo and Salawati

Myrsinaceae: *Aegiceras corniculatum* (L.) Blanco.

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