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Diversity of Mangrove Plants in Karimunjawa National Park

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Abstract Karimunjawa National Park (TNK) area is ± 111,625 hectares covering 27 islands located in Jepara Regency, Central Java at the northern tip of Java Island. Karimunjawa became Karimunjawa National Park (TNK) based on the Decree of the Minister of Forestry and Plantation No.78/Kpts-II/1999 because it has high diversity. The complexity of ecosystems in TNK is interesting to study, such as coral reef ecosystems, mangrove forests, lowland tropical rainforests, seagrass meadows, seaweed, and coastal forests. The mangrove forest in Karimunjawa National Park is a unique ecosystem because it consists of many mangrove species. However, data on the diversity of mangrove species on this island has not been widely described. This study aims to reveal mangrove diversity in Karimunjawa National Park as a rescue strategy and explore the potential of mangrove biodiversity. This research is a descriptive study using the cruising method to explore mangrove species diversity. The location of mangrove diversity exploration is mangrove forest in Karimunjawa National Park. The results found 14 families consisting of 38 mangrove species. Among the 38 species, 24 species are true mangroves, while the other 14 species are associated with mangroves.

Keywords: Association mangrove; Diversity; Karimunjawa National Park; Mangrove; True mangrove

Introduction

Indonesia has high diversity so that it is included as a "megabiodiversity country", with an estimated 30,000-40,000 species of seed plants spread across 74 types of ecosystems (BAPPENAS, 2021). One of the seed plants that attracts attention is mangrove. Indonesia has the largest mangrove forest, which is 42,278 km^2 (Sadeer & Mahomoodally, 2022). Indonesian mangroves are among the largest in the world, covering more than 24 percent of the total area of the world's mangroves (KLHK, 2023). According to Noor et al. (2006), Indonesia has 202 types of mangrove plants, consisting of 89 types of trees, 5 types of palms, 19 types of climbers, 44 types of terrestrial herbs, 44 types of epiphytes and 1 type of fern. Among the 202 types of mangroves, 43 types are true mangroves, while the other types are associate mangroves.

Mangroves are a group of plants that can live in tidal areas (Sadeer & Mahomoodally, 2022), in transitional areas between fresh water and sea water (Tihurua et al., 2020). Mangrove plants have the ability to adapt to extreme environments, for example environments that are always flooded, have high salt content, and unstable soil conditions. Salt stress is a condition of excessive salt accumulation in the soil which ultimately results in stunted plant growth and causes plant death (Sudhir et al., 2022). According to Acharya et al. (2023) mangroves, they develop the ability to adapt to saline conditions through: salt excluders, salt secretors, salt accumulators.

Karimunjawa became Karimunjawa National Park (TNK) based on the Decree of the Minister of Forestry

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and Plantations No.78/Kpts-II/1999 concerning Changes in the Function of the Karimunjawa Nature Reserve Area and the Surrounding Sea Waters. The TNK area of ± 111,625 hectares covers 27 island clusters located in Jepara Regency, Central Java at the northern tip of Java Island (Pratiwi et al., 2021). The complexity of the ecosystem in TNK is interesting to study, such as coral reef ecosystems, mangrove forests, lowland tropical rainforests, seagrass beds, seaweed, and coastal forests (Wungo et al., 2020). Several types of TNK mangroves that have been identified include *Rhizophora apiculata*, *Rhizophora stylosa*, *Sonneratia alba*, *Lumnitzera racemosa*, *Ceriops tagal*, *Excoecaria agallocha*, *Rhizophora mucronata*, *Bruguiera gymnorrhiza*, *Bruguiera cylindrica*, *Avicennia marina*, *Sonneratia alba*, and *Avicennia officinalis* (Purnomo & Ngaliyan, 2020; Hartoko et al., 2013). Mangroves in Karimunjawa National Park are dominated by *Rhizophora* (Sipayung, 2023).

Although there are various types of mangroves in Karimunjawa National Park, there is not much data that provides information about the diversity of its types. This study aims to reveal the diversity of mangrove plant species in the Karimunjawa National Park area based on their morphological characteristics. It is hoped that this study can contribute to completing the data on the diversity of mangrove species. The novelty of this research is to describe the characteristics and role of mangrove species in Karimunjawa National Park. This research is important as a strategy to save mangroves by exploring the local potential of mangroves in Karimunjawa National Park. By knowing the extensive role of mangroves, the community will maintain the survival of mangroves.

Method

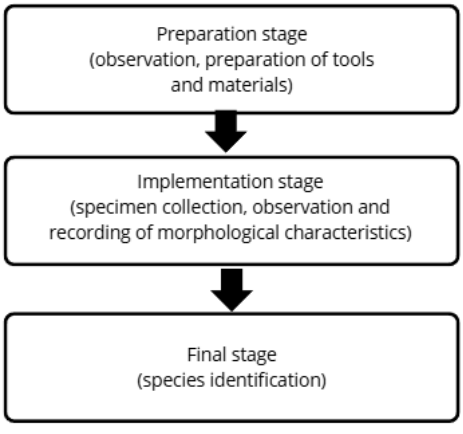

Figure 1. Flow of research stages

The method used in this study is a descriptive method with field observation techniques. Observations were carried out on July 9-14, 2024 in the mangrove forest area of Karimunjawa National Park. Observations and specimen collection were carried out using the exploration method, namely by exploring the mangrove forest area. The data obtained in the field are in the form of morphological characteristics, which are described based on the characteristics and characteristics of plants, then the similarities and differences are described with the help of the Mangrove Introduction Guide book (Sadeer & Mahomoodally, 2022; Noor et al., 2006; Djamaluddin, 2018). Data were analyzed using the description method to species diversity. Mangrove plant data were described and their taxonomic levels were created from kingdom to species by utilizing the facilities of the sites http://powo.science.kew.org/ and https://www.gbif.org/, then analyzed tabulated and accompanied by images of mangrove types.

Result and Discussion

There are 38 species of mangroves found in the Karimunjawa National Park area, Jepara, Central Java, consisting of 21 families (Table 1). The results of exploration and identification of mangrove plants in Karimunjawa National Park are higher than other studies that report TNK mangrove species that have been identified include *Rhizophora apiculata*, *Rhizophora stylosa*, *Sonneratia alba*, *Lumnitzera racemosa*, *Ceriops tagal*, *Excoecaria agallocha*, *Rhizophora mucronata*, *Bruguiera gymnorrhiza*, *Bruguiera cylindrica*, *Avicennia marina*, *Sonneratia alba*, and *Avicennia officinalis* (Purnomo & Ngaliyan, 2020; Hartoko et al., 2013).

Table 1. Mangrove plants in Karimunjawa National Park

Family	Species	Information
Acanthaceae	*Acanthus ilicifolius*	True mangrove
	Acanthus ebracteatus	True mangrove
	Avicennia marina	True mangrove
Pteridaceae	*Acrostichum aureum*	True mangrove
	Acrostichum speciosum	True mangrove
Primrose	*Aegiceras cormiculatum*	True mangrove
Rhizophoraceae	*Bruguiera cylindrica*	True mangrove
	Bruguiera gymnorrhiza	True mangrove
	Bruguiera sexangula	True mangrove
	Rhizophora apiculata	True mangrove
	Rhizophora stylosa	True mangrove
	Rhizopora lamarckii	True mangrove
	Rhizopora mucronata	True mangrove
	Ceriops tagal	True mangrove

Family	Species	Information
Euphorbiaceae	*Exoecaria agallocha*	True mangrove
Sonneratiaceae	*Sonneratia alba*	True mangrove
	Sonneratia ovata	True mangrove
Rubiaceae	*Scyphiphora hydrophyllaceae*	True mangrove
	Morinda citrifolia	Mangrove association
Arecaceae	*Nypa fruticans*	True mangrove
Maliaceae	*Xylocarous granatum*	True mangrove
	Xylocarpus moluccensis	True mangrove
Lytraceae	*Pemphis acidula*	True mangrove
Combretaceae	*Lumnitzera littorea*	True mangrove
	Lumnitzera racemosa	True mangrove
	Terminalia catappa	Mangrove association
Verbena	*Stachytarpheta jamaicensis*	Mangrove association
	Lantana camara	Mangrove association
Calophyllaceae	*Calophyllum inophyllum*	Mangrove association
Convolvulaceae	*Ipomoea pes-caprae*	Mangrove association
Aizoaceae	*Sesuvium portulacastrum*	Mangrove association
Goodeniaceae	*Scaevola taccada*	Mangrove association
Ebenaceae	*Dryosphyros sp*	Mangrove association
Melastomataceae	*Melastoma candidum*	Mangrove association
Lamiaceae	*Clerodendrum inerme*	Mangrove association
Pandanus	*Pandanus tectorius*	Mangrove association
Malvaceae	*Hibiscus tiliaceus*	Mangrove association
	Thespesia papulnea	Mangrove association

True Mangrove

True mangroves are a type of plant that truly grows in salty intertidal habitats (Djamaluddin, 2018), the habitat of coastal ecosystems that experience ebb and flow, high salinity changes, unstable substrates and low oxygen (Wang et al., 2011). In the study, 24 species were found to be true mangroves, consisting of *Acanthus ilicifolius* Bush habit, up to 2 m high. Branches are generally upright but tend to be thin according to age. Branching is not much and generally appear from older parts. Aerial roots emerge from the lower surface of the horizontal stem. Single leaves, opposite, lanceolate, tapering tips, smooth surface, sharp thorny edges. Size: 9-30 x 4-12 cm. Racemose inflorescence, terminal. Bisexual flowers; 4 sepals, green; 4 petals, simpetalous, white base, bluish middle to tip. The length of the flower bunch is 10-20 cm, while the flower itself is 4-5 cm. Jeruju leaves can be processed into jeruju tea (Mardhia et al., 2019). Jeruju leaf extract *A. ilicifolius* has high bioactivity so it has the potential to treat diseases (Johannes & Sjafaraenan, 2017), contains alkaloid, flavonoid, phenolic and saponin compounds, as an ingredient in anti-acne cream (Nusaibah et al., 2021), as a herbal drink (Rahayu & Idris, 2024). Leaf flour can be used as a natural preservative (Jayadi et al., 2018).

A. ebracteatus almost the same as *A. ilicifolius*, but the leaf edges are generally flat. Single leaves, opposite, lanceolate in shape, tapering at the tip with a size of 7-20 x 4-10 cm. The flower crown is light blue to bright purple, sometimes slightly white at the tip. The length of the flower cluster is shorter than *A. ilicifolius*, while the flower itself is 2-2.50 cm. The fruit can be used as a blood purifier and to treat sunburn while the leaves are used to treat rheumatism (Samsi et al., 2022). *A. ebracteatus* extract can be used as a hair loss prevention drug (Wisuitiprot et al., 2022), proven safe and effective for the treatment of skin aging as indicated by its antioxidant, anti-melanogenesis, collagen stimulant, anti-fame and anti-aging activity (Kanlayavattanakul et al., 2023), can heal wounds and photoprotection, and is the main source of verbascoside so that it can be used for the development of innovative skin care products (Kanlayavattanakul et al., 2024). Leaf extract has neuroprotective activity against glutamate induced oxidative injury (Prasansuklab & Tencomnao, 2018).

Avicennia marina. Tree habit, reaching 8 m in height, there are pneumatophores in the form of pencil roots. Stems are upright, there is no white latex; grayish-green bark, not scaly. There are no stipules. Single leaves, opposite, elliptical to obovate, the apex is pointed, glossy green adaxial, whitish abaxial with salt crystal spots, size: 9 x 4.5 cm. Flowers are clustered at the end of the stalk. Bisexual flowers; green petals; 4 sepals; orange-yellow crown; 4 petals; 4 stamens, yellow; solitary pistil. Simple fruit, yellowish green, viviparous, cone-shaped to round. Cryptoviviparous reproduction, seeds grow directly when they fall to the ground. *Avicennia marina* can grow back even if it falls. *A. marina* leaf extract has antioxidant activity (Wulandari et al., 2022), accelerates the wound healing process (Sumintarti et al., 2022), contains bioactive compounds that have the potential as anticancer, antimicrobial, anti-inflammatory, anti-insecticide and antioxidant (Rozirwan et al., 2022). Seed extract has the potential as an antibacterial (Naidu et al., 2019; Audah et al., 2020). Some construction activities such as bridges, fences or fishing gear can utilize Avicennia wood (Budiarti et al., 2023).

Acrostichum aureum belongs to the fern group, reaching 3 m in height. Compound leaves, pinnate; young leaves roll upwards; alternate leaflets, lanceolate; sterile leaflets at the end of the stalk; fertile leaflets at the end of the stalk, sporangia cover the abaxial surface when mature. *A. aureum* can be used to control Mn metal in waters (Hanin & Pratiwi, 2017). Young leaves can be consumed as vegetables (Samsi et al., 2022). *A. aureum* can be used for new bioactive compounds that can be useful in treating various diseases (Akinwumi et al.,

2022). Leaf extracts contain high flavonoids and can be categorized as strong antioxidants (Hanin & Pratiwi, 2017).

Acrostichum speciosum (sea fern) belongs to the fern group. Bush habit, clustered, height can reach 2 m. Stems form rhizomes, Compound leaves, pinnate; young leaves roll up; alternate leaflets, lanceolate in shape with a size of 28 x 10 cm, the lower surface is fertile and the upper surface is sterile. Sterile leaves have smaller and narrower tips. Reddish brown when young, green when mature, sori cover the lower surface of fertile leaves. The lower surface of fertile leaves is dark brown and covered with sporangia, and the young leaves are greenish brown. Rhizome extract is used to accelerate wound healing (Herman et al., 2013).

Aegiceras cormiculatum. Small tree habit, up to 8 meters tall. Stem erect, no white latex; gray to brownish bark; young stems reddish. Stipules absent. Roots creeping on the ground without pneumatophores. Single leaves, alternate, obovate obovate, rounded tips, entire leaf margins, size 11 x 7.50 cm, glossy green adaxial, pale abaxial. Compound inflorescence, umbellate, terminal. Bisexual flowers; green calyx, curled; sepals 5; white crown; petals 5; stamens 5, white; solitary pistil, white. Single fruit, cryptoviviparous, hypocotyl grows towards the fruit stalk. Various parts of the Aegiceras corniculatum plant *can* be used for traditional medicine because of its potential therapeutic effects in treating diseases such as asthma, microbial infections, diabetes, pain relief, inflammation, cancer, and arthritis (Sarkar et al., 2024). Leaves have antibacterial activity and have been shown to inhibit the growth of *E. coli* and *Bacillus subtilis bacteria* (Janmanchi et al., 2017). Fruits have better antioxidant potential than leaves (Imra et al., 2022). In order, the greatest antioxidant potential is fruit, roots, bark and leaves (Mohapatra & Basak, 2021). Saponins from *A. corniculatum* could be a potential candidate for treating cancer and inflammatory diseases (Vinh et al., 2020).

B. cylindrica. Tree habitus, up to 10 m tall with knee root pneumatophores. Stem erect, no white sap; smooth and grayish bark, mottled. Single leaves, opposite, elliptical, rounded tips, size of old leaves 5 - 9 x 3.30 - 4.3 cm. Cyme inflorescence, 2-3 flowered axils. Flowers are bisexual, grouped in 2-3 flower groups; number of sepals 8 yellowish green; number of petals 8 with pale yellow white color; green calyx, sulcate, calyx lobes 1-2 cm, reflex; sepals 6-8, stiff; white crown; calyx 6-8, hairy, hairy apex; hairless stamens; solitary pistils cylindrical fruit, brownish color; hypocotyl color light green to purplish with a length of 3-7.5 cm diameter 05- 0.80 mm. Viviparous; hypocotyl cylindrical, hanging. Leaf extract of *B. cylindrica* is reported to contain flavones, fatty acids, terpenes, and carboxylic acids (Dahibhate & Kumar, 2022). All parts of the plant can be used as a medicine for hepatitis, liver disorders, jaundice, diabetes, hypertension, boils, stopping bleeding, anti-inflammatory and rheumatic (Pitchaipillai & Ponniah, 2016 Eldeen et al., 2019).

Bruguiera gymnorrhiza. Tree habit, reaching 10 m in height with plank roots and pneumatophores of knee roots. Stems are erect, without white sap; bark is blackish brown with lenticels. Single leaves, opposite, elliptical, rounded tips, measuring 4.50-7 x 8.50-22 cm. Bisexual flowers; red petals; 10-14 sepals, stiff; yellowish crown; 10-14 petals, hairy, hairy apex; hairless stamens; solitary pistils. Simple fruit, viviparous; cylindrical hypocotyl, hanging. Stems are used as building materials and to make charcoal (Samsi et al., 2022). Leaf extract effectively inhibits the growth of *Enterococcus faecalis bacteria* (Wicaksono et al., 2024) and the pathogenic bacteria *P. aeruginosa* (Effendi et al., 2023), so it has the potential to be an antibacterial (Rahmawati et al., 2024; Audah et al., 2020). *B. gymnorrhiza* L. leaves are rich in polyphenols that can repair liver tissue through their antioxidant effects (Sur et al., 2016), Medication for ulcers and diarrhea (Ernikawati et al., 2023). Leaf and bark extracts have the potential to be used as batik dyes (Pringgenies et al., 2023). *B. gymnorrhiza* fruit flour contains minerals such as calcium, potassium, magnesium, and zinc (Launda et al., 2023). Propagule fruit can treat mangir (fungus on the tongue) in toddlers and itching (Abubakar et al., 2019).

Bruguiera sexangula. Tree habit, reaching 20 m in height. There are knee root pneumatophores, upright stems, no white sap; brownish gray bark, spots, lenticels. Single leaves, opposite, elliptical, rounded tips, size 8-16 x 3-6 cm. Bisexual flowers; yellow to orange petals; 10-14 sepals, stiff; yellowish crown; 10-14 petals, hairy, apex hairless; free stamens; solitary pistil. Simple fruit, viviparous; cylindrical hypocotyl. For firewood, poles and charcoal. The fruit is reported to be used to treat herpes, the roots and leaves are used to treat sunburn. In Sulawesi the fruit is eaten after being soaked and boiled.

Rhizophora apiculata. Tree habit, height reaches 30 m, trunk diameter up to 50 cm. Roots have special characteristics, height up to 5 meters, equipped with aerial roots emerging from branches. The bark is dark gray. The leaves are dark green, slightly lighter in the middle, while the bottom is reddish. Leaf stalks measuring 17-35 mm are reddish. Single leaf type, located opposite. The leaves are elliptical, tapering at the ends, 7-19 x 3.50-8 cm long. Bisexual flowers, yellowish flower heads located in the leaf axils, in groups (2 flowers per group), 4 crowns, yellow-white, no hair, 9-11 mm long. The flower petals are 4, brownish yellow, curved. The stamens are 11-12, stalkless. The rough fruit is round and elongated to pear-shaped, brown in color, 2-3.50 cm long, containing one fertile seed. The hypocotyl is cylindrical, nodules, orange-green in color.

Size: Hypocotyl is 18-38 cm long and 1-2 cm in diameter. Wood is used for building materials, firewood and charcoal. Young roots can treat mangir (fungus on the tongue) in toddlers and open wounds caused by sharp objects, while the bark and leaves are efficacious as a medicine for toothache (Abubakar et al., 2019). *R. apiculata* dry leaf extract is reported to comprise bioactive compounds of alkaloid, flavonoid, phenolic and saponin bioactive compound groups (Runtuboi et al., 2024), have antibacterial effects (Sormin et al., 2021), decreasing blood sugar levels (Tandi et al., 2023), treat vomiting, neutralizingtoxins, hepatitis, and bacteria-inhibiting (Ernikawati et al., 2023). Utilization in the health sector as an astringent, antiseptic, anti-haemorragic, medicine for diarrhea, nausea, typhoid fever, diabetes and hepatitis.

Rhizophora stylosa. Tree habit, reaching 10 m in height. Smooth bark, gray to black in color. There are taproots that can reach 3 m in length, and aerial roots emerge from the lower branches. The leaves are elliptical, widening at the tip, regularly spotted on the lower layer. The leaf stalk is green, the stalk length is 1-3.50 cm. The single leaf type is opposite. Bisexual flowers, each attached to an individual stalk that is 2.50-5 cm long, located in the leaf axil., in groups (8-16 flowers per group), the crown is 4 white, there are hairs. 8 mm. The petals are 4, the color is yellow green, the length is 13-19 mm. There are 8 stamens, and a style that is 4-6 mm long. The fruit is pear-shaped, brown, contains 1 fertile seed, 2.50-4 cm long. The hypocotyl is cylindrical, has rather smooth nodules, 20-35 cm long and 1.50-2.00 cm in diameter. As a building material, firewood, and charcoal. Young roots can treat mangir (fungus on the tongue) in toddlers and open wounds caused by sharp objects, while the bark and leaves are efficacious as a medicine for toothache (Abubakar et al., 2019).

Rhizophora mucronata. Tree habitus with a height of up to 27 m. The trunk diameter reaches 70 cm, dark to black skin. There are supporting roots and aerial roots that grow from the lower branches. The leaves are elliptical to elongated round, the tips are tapered, the size is 11-23 x 5-13 cm. The leaf stalk is green, 2.50-5.50 cm long. The leaf pinna is located at the base of the leaf stalk measuring 5.50-8.50 cm, opposite. Bisexual flowers, in groups (4-8 flowers per group), each attached to an individual stalk that is 2.50-5 cm long. Flowers are located in the leaf axils, the crown is 4, white, there are 9 mm hairs. The petals are 4, pale yellow, 13-19 mm long. The stamens are 8, stalkless. The fruit is oval/long, measuring 5-7 cm, brownish green, rough at the base, with a single seed. The hypocotyl is cylindrical, rough and nodular, 36-70 cm long and 2-3 cm in diameter. The wood is used as charcoal, firewood, and building materials, the bark and propagules for natural dyes and leather tanning (Setyawan et al., 2022). *R. mucronata* can inhibit the growth and modulate the virulence factors of aquaculture pathogens (Kannappan et al., 2021). The bark contains saponin, steroid, flavonoid and anthraquinone compounds and can act as antioxidants (Sudjarwo & Hukmiyah, 2017; Aminah & Tanjung, 2016). The fruit is used as a medicine for diabetes, puffiness, stretching (Ernikawati et al., 2023).

Ceriops tagal. Tree habit, up to 10 m tall, with knee root pneumatophores. Stem erect, with white sap; bark grayish with spots. Single leaves, opposite, obovate to elliptical, 1-10 x 2-3.50 cm in size, shiny green, edges curled inward. Flowers clustered at the end of the bunch, located in the leaf axils, 4-10 flowers. Bisexual flowers; yellowish green petals; 5 sepals, stiff; brownish white crown; 5 petals; free stamens; solitary pistil. Simple fruit, viviparous; hypocotyl rounded, serrated, scaly. Bark extract is useful for childbirth. Tannin is produced from the bark. Dyes are produced from the bark and wood. Wood is useful for building materials, railroad ties, and tool handles, because of its resistance when soaked in salt water. Good firewood and is one of the strongest woods among the types of mangroves. Various parts of the plant have antibacterial, antiviral, antioxidant, antifeedant, antifouling and anticancer activities (Manohar et al., 2023).

Exoecaria agallocha. Tree habit, reaching 15 m in height. Stem erect, contains white and sticky sap; smooth, grayish bark. Roots creep along the surface of the soil, covered with lenticels. Leaves single, crossed, elliptical, pointed tip, finely serrated edge, dark green, size 6.50-10.50 x 3.50-5 cm. The inflorescence is climbing, dioecious, located in the leaf axil. Male flowers have petals; sepals 3, very small, about 0.50-1 mm; stamens 3. Female flowers have petals; petals 3, very small, about 0.50-1 mm; carpels 3, ovary trilocular. Simple fruit, 3 ovaries. Leaf extract contains antioxidants and has the potential to be developed as a breast cancer drug (Bhuvaneswari et al., 2017). The sap has toxic activity against snails that interfere with shrimp growth so it can be used as a pesticide (Setyastuti et al., 2022). This plant plays a role in treating leprosy, anti-bloating and reducing lymph and has anti-pyretic and anti-inflammatory effects (Susanti et al., 2022).

Sonneratia alba. Tree habitus, reaching 15 m in height. Bark is white to brown. Roots spread underground and emerge to the surface as blunt cone-shaped breathing roots, up to 25 cm high. Leaves are inverted oval, rounded at the tip, 5-12.50 x 3-9 cm. Leaf stalks are 6-15 mm long. Single leaf type, opposite. Bisexual flowers, flower stalks 1 cm long are located at the end or on small branches. Solitary-group flowers (1-3 flowers per group), white crown, easy to fall off, 6-8 petals, green outside, reddish inside, resembles a bell, 2-2.50 cm long. Many stamens, white tips and yellow

bases, easy to fall off. Fruit resembles a ball, stalked at the end and the base is wrapped in flower petals. The fruit contains many seeds (150-200 seeds) and will not open when ripe. The fruit diameter is 3.50-4.50 cm. The sour fruit can be eaten. Young fruit can treat mangir (fungus on toddler's tongue), while the bark can increase appetite and stamina and treat rheumatism (Abubakar et al., 2019).

Sonneratia ovata. Tree habitus, small or medium size, reaching 5 m in height, with young branches in the form of a rectangle and vertical respiratory roots. Leaves are oval, the tips are rounded, 4-10 x 3-9 cm, single type, facing. Leaf stalks are 2-15 mm long, Flower stalks are straight, 1-2 cm long. Flower buds are oval and wide and covered by small protrusions, located at the tip, solitary-group (there are 1-3 flowers per group). There is no crown, the inner petals are red. Stamens are numerous, white and fall off easily. The fruit is ball-shaped, the tip is stalked and the base is wrapped in flower petals. The size is almost the same as *S. alba*, diameter 3-5 cm. Firewood. Young fruit can be eaten as rujakan. *Sonneratia ovata* fruit contains flavonoids, saponins, carotenoids, and steroids (Astuti et al., 2021).

Scyphiphora hydrophyllaceae. Habitus upright shrub, evergreen, often has many branches, height reaches 3 m. Rough brown bark, young branches have resin, sometimes there are stilt roots in large individuals. Leaves: Leaves are leathery and shiny. Glandular leaflets, located at the base of the leaf stalk forming a hairy cover. Straight leaf stalks up to 13 mm long. Unit & Location: simple & opposite. Shape: inverted ovate. Tip: rounded. Size: 4-9 x 2-5 cm. Flowers: White, almost stalkless, bisexual, found in clusters up to 15 mm long. Location: in the leaf axils. Formation: groups (3-7 flowers per group). Corolla: 4-5; white-slightly red, elliptical, 2-4 x 2- 2.50 mm, mouth coarsely hairy. Petals: 4-5; bowl-shaped, bottom like a tube (length 5 mm). Stamens: 4-5. Fruit: Cylindrical, green to brown, longitudinally veined and has the remains of calyx leaves. Does not open when ripe. There are 4 cylindrical seeds. Size: fruit: 8 mm long, seeds: 1 x 2 mm. The wood can possibly be used for eating utensils, such as spoons. The leaves can be used to treat stomach aches. cytotoxicity and antioxidant effects on *S. hydrophyllacea* potentially developed as anticancer (Samarakoon et al., 2017).

Nypa fruticans. Palma without a stem on the surface, forming a clump. The stem is underground, strong and forked. Height can reach 4-9 m. Leaves: Like the arrangement of coconut leaves. The length of the leaf bunch/stem is 4 - 9 m. There are 100 - 120 leaflets on each leaf bunch, shiny green on the upper surface and powdery on the underside. Shape: lanceolate. Tip: tapering. Size: 60-130 x 5-8 cm. Flowers: Bisexual flower clusters grow from near the top of the stem on a 1-2 m long stalk. Female flowers form a circular head with a diameter of 25-30 cm. Male flowers are bright yellow, located under the flower head. Fruit: Round fruit, brown, stiff and fibrous. Each fruit contains one egg-shaped seed. Size: fruit head diameter: up to 45 cm. Seed diameter: 4-5 cm. Nipah has various economic and ecological benefits (Budiarti et al., 2023). A large amount of sweet syrup can be made from the stems, if the flowers are picked at the right time. Used to produce alcohol and sugar. If managed properly, the sugar production is better than cane sugar, and has a higher sucrose content. The leaves are used for making umbrellas, hats, mats, baskets and cigarette paper. The seeds are edible. After being processed, the leaf stem fibers can also be made into rope and bristles. Leaves: can replace cigarette paper (Samsi et al., 2022). The tips of young leaves can treat open wounds caused by sharp objects (Abubakar et al., 2019).

Xylocarpus granatum. Trees can reach a height of 10-20 m. It has plank roots that spread to the sides, twisting and forming gaps. Trunks often have holes, especially in older trees. The bark is light brown-yellowish, thin and peeling, while on young branches, the bark is wrinkled. Leaves: Rather thick, the leaves are arranged in pairs (generally 2 pairs per stem) and some are solitary. Unit & Location: compound & opposite. Shape: elliptical - inverted ovoid. Edge: rounded. Size: 4.50 - 17 cm x 2.50 - 9 cm. Flowers: Flowers consist of two sexes or female only. The flower clusters (2-7 cm long) emerge from the base (axil) of the leaf stalk and the flower stalk is 4-8 mm long. Location: in the armpit. Formation: random clusters (8-20 flowers per cluster). Corolla: 4; oval, rounded edges, greenish white, 5-7 mm long. Petals: 4 lobes; light yellow, 3 mm long. Stamens: creamy white and fused in a tube. Fruit: Ball-like (coconut), weight can be 1-2 kg, skinned, brownish green. The fruit hangs on branches near the ground and is somewhat hidden. Inside the fruit are 6-16 large, woody, tetrahedral seeds. The arrangement of the seeds inside the fruit is confusing like a puzzle (in English called 'puzzle fruit'). The fruit will split when dry. Size: fruit: diameter 10-20 cm. The wood is only available in small sizes, sometimes used as a material for boat building. The bark is collected for its high tannin content (> 24% dry weight). Stem: used as a material for making boats and building houses (Samsi et al., 2022). The bark can be used to restore stamina for mothers after giving birth while the fruit can be used as powder (Abubakar et al., 2019).

Xylocarpus molucensis. The tree is between 5-20 m tall. It has a taper-shaped breathing root. The bark is smooth, while the main trunk has deep surface lines. Leaves: Thinner than X. granatum, leaf arrangement in pairs (usually 2-3 ps per stalk) and some are solitary. Unit & location: compound & opposite. Shape: elliptical - inverted ovate. Tip: tapering. Size: 4-12 cm x 2-6.50 cm. Flowers: Consists of two sexes or female only. Flower

clusters (6-18.50 cm long) emerge from the leaf stalk axils and flower stalks are 2-10 mm long. Location: in the axils. Formation: random clusters (10-35 flowers per cluster). Crown leaves: 4; yellowish white, oval, rounded edges, 6-7 mm long. Flower petals: 4 lobes; yellowish green, about 1.50 mm long. Stamens: 8, fused; creamy white and about 2 mm high. Fruit: Green, round like Bangkok guava, skinned on the surface and inside there are 4-10 tetrahedral shaped seeds. Size: fruit: diameter 8-15 cm. The wood is used for firewood, making houses, boats and sometimes for keris handles. The bark can be used to restore stamina of mothers after giving birth while the fruit can be used as powder (Abubakar et al., 2019).

Pemphis acidula. Tree spreading densely/widely on the ground surface, with a height of up to 3 m. The bark is gray to brown. The respiratory roots are not very developed. Leaves: Thick (up to 3 mm) fleshy, stiff, leathery and slightly curved/bent inward. Unit & Location: simple and opposite. Shape: elliptical to inverted ovate. Tip: rounded to bluntly pointed. Size: 1-3 cm long. Flowers: Bell-shaped. Location: in the leaf axils. Formation: in groups (there are 1 to several flowers per group). Crown leaves: 6, pure white, the middle part is slightly purplish-yellowish. Petals: 12, green. Stamens: 12 - 18 in number. Fruit: Shaped like an ice cream bowl, brown, hairy surface, inside there are 20-30 very small seeds. Size: fruit diameter 3-5 mm, length 10 mm. *Pemphis acidula* has potential as environmental bio-indicator (Al Idrus et al., 2023).

Lumnitzera littorea. The tree is evergreen and grows scattered, the height of the tree can reach 25 m, although generally lower. The respiratory roots are knee-shaped, dark brown in color and the bark has longitudinal cracks/cracks. Leaves: The leaves are rather thick, fleshy, hard/stiff, and clustered at the end of the branch. The length of the leaf stalk reaches 5 mm. Unit & Location: simple, crossed. Shape: inverted oval. Tip: rounded. Size: 2-8 x 1-2.50 cm. Flowers: Bisexual flowers, bright red, fragrant, and filled with nectar. The length of the flower stalk reaches 3 mm, the bunch is 2-3 cm. Has two oval-shaped leaflets and measures 1 mm at the base. Location: at the tip. Formation: spikelet. Crown leaves: 5; red, 4-6 x 1.50-2 mm. Flower petals: 5; green 1 x-12 mm. Stamens: < 10; The length of the stamens is twice the size of the crown leaves. Fruit: Fruit shaped like a pot/flower vase/ellipse, purplish green, rather hard and bony. Size: length 9-20 mm; Diameter 4-5 mm. With its attractive appearance and rose-like scent, the wood is very suitable to be used as a material for making cabinets and other furniture. The wood of this tree can be used for household furniture (Samsi et al., 2022).

Lumnitzera racemosa. Shrub or small tree, evergreen with a height of up to 8 m. The bark is reddish-brown, has longitudinal cracks (especially on old stems), and has no respiratory roots. Leaves: Leaves are rather thick, fleshy, hard/stiff, and clustered at the end of the branch. The length of the leaf stalk reaches 10 mm. Unit & Location: simple, crossed. Shape: narrowed oval. Tip: rounded. Size: 2-10 x 1-2.50 cm. Flowers: Bisexual flowers, without stalks, bright white, filled with nectar. The length of the bunch is 1-2 cm. Has two oval-shaped leaflets, 1.50 mm long at the base. Location: at the tip or in the axil. Formation: spikelet. Corolla: 5; white, 2-4 x 7-8 mm. Petals: 5; green (6-8 mm). Stamens: < 10; The length of the stamens is the same or slightly longer than the corolla. Fruit: The fruit is bloated/elliptical in shape, yellowish green, fibrous, woody and dense. Size: length 7-12 mm; Diameter 3-5 mm. The wood is hard and durable, suitable for various building materials, such as bridges, ships, furniture and so on. Its size is smaller than *L. littorea*, so it is very rare to find large wood. The bark is sometimes used as a coating material. *Lumnitzera racemosa* contains tannins, flavonoids, terpenes, terpenoids, phenolic compounds, phytosterols that have pharmacological activity, so they have potential as antioxidants (Poncowati et al., 2022).

Mangrove Association

Associated mangroves are mangroves that grow behind the true mangrove zone, are tolerant of salinity, are transitional vegetation to land or sea, and can interact with true mangroves (Wang et al., 2011). In the study, 14 species were found to be associated mangroves, consisting of: *Morinda citrifolia*. Shrub or small tree that grows crooked, 3-8 m high, many branches with rectangular twigs. Leaves: Thick, short-stemmed, shiny dark green, flat leaf edges. Leaf veins are pinnate towards the edge of the leaf and look very clear. Unit & Location: simple and opposite. Shape: oval to elliptical. Tip: tapered. Size: 10-40 x 5-17 cm. Flowers: White, fragrant and easy to fall off. Location: in the leaf axils. Formation: umbrella with 5-8 flowers. Crown leaves: 5 in number, white. Fruit: Oval like a capsule and full of bumps. When still raw it is light green, when ripe it is slightly yellowish, soft and juicy. Small seeds, blackish brown and many. Size: 5-10 cm long. The roots are used to color batik and pandan weaving, young leaves are usually steamed and boiled as vegetables or to wrap fish. Young fruit is boiled for lalab; half-ripe fruit for rujak, and ripe fruit is used to clean rust on metal or for shampooing. In addition, the roots, leaves, fruit, flowers or bark of this plant can also be used as a medicine for coughs, mouth ulcers, high blood pressure, gallbladder inflammation, smooth urination, dysentery, liver disease, worms, chicken pox, back pain, stomach ache, etc. Noni fruit extract as a source of natural antioxidants can maintain the quality of Y chromosome spermatozoa (Firmiaty et al., 2023). Ethanol Extract of

Noni (Morinda citrifolia) Lowers Blood Glucose Levels (Arjita et al., 2023).

Terminalia catappa. Deciduous tree 10-35 m tall. Young branches are thick and densely covered with hairs that later fall off. The crown is horizontally layered, a condition especially evident in young trees. Leaves: Very broad, generally with 6-9 pairs of widely spaced veins, with a gland located at the base of one of the central veins. The leaves turn pink or red shortly before falling, giving the tree canopy a red appearance. Units & Location: Simple and crossed. Shape: Obovate. Tip: Rounded. Size: 8-25 x 5-14 cm (sometimes up to 30 cm long). Flowers: Flower clusters (8-16 cm long) covered with fine hairs. Flowers are white or pale green and are not pediceled. Most of the flowers are male, with or without short pedicels. Location: In the leaf axils. Formation: Spikelets. Petals: Smooth on the inside. Fruit: Appearance like almonds. Fibrous and very hard shell. Size 5-7 cm x 4x5.50 cm. The skin of the fruit is green to yellowish green (shiny) in the middle, then changes to dark red. Ecology: Its distribution is very wide. Grows on sandy or rocky beaches and the edge of the land from mangroves to far inland. The distribution of fruit is done through water or by fruit-eating bats. The tree sheds its leaves (when the color changes to red) once a year, usually twice a year (in Java in January or February and July or August). Benefits: Often planted as a street shade tree. The wood is red and has good quality, used as a building material and for making boats. The seeds of the fruit are edible and contain fatty and clear oil. Tannin is used to treat dysentery and for tanning leather. Leaves are often used to treat rheumatism. The leaves have potential as animal feed (Suhubdy et al., 2023).

Stachytarpheta jamaicensis. Annual herb, grows upright and spreads out to the side forming a bush, reaching 1 meter in height. Leaves: The surface of the leaves is rough and the lines / grooves on the surface are clearly visible. Unit & Location: simple and opposite. Shape: oval, serrated edges, hairless. Tip: pointed. Size: 2.50-6 x 1.00-3.50 cm. Flowers: Found in bunches that are 4-20 cm long like whips, flowers sitting without stalks. Flowers bloom not simultaneously, small in size, bluish purple and white. Location: in the leaf axils. Formation: grains on long bunches. Ecology: Found on pond embankments, abandoned land areas, in open and dry locations and receive strong sunlight. Distribution: Throughout Indonesia. Abundance: Unknown. Benefits: Often kept as a hedge plant because it has benefits as a medicinal ingredient, for example to treat infections and stones in the urinary tract, rheumatism, sore throat, blood cleanser, irregular menstruation, vaginal discharge and hepatitis A. *S. jamaicensis* has antimicrobial and antifungal effects (Liew & Yong, 2016). The leaf extract has antibacterial activity against S.aureus, E.coli and has potential as an antioxidant (Kumala & Bekti, 2016).

Calophyllum inophyllum. Dark colored tree, densely leafy, 10-30 m tall, usually grows slightly crooked, leaning or even parallel to the ground. Has white or yellow sticky sap. Leaves: Have many veins with parallel and smooth lateral positions. The upper part of the leaf is dark green and shiny, the lower part is slightly yellowish green. Unit & Location: simple and opposite. Shape: elliptical to elongated round, somewhat similar to *Rhizopora mucronata* leaves (mangrove species). Tip: rounded. Size: 10-21.50 x 6-11 cm. Flowers: Bisexual, flower clusters up to 15 cm long and have 5-15 flowers per cluster. Location: in the axils. Formation: clustered, hanging like an umbrella. Crown leaves: 4, white and yellow, fragrant, 2-3 cm in diameter. Flower petals: 4, two of the flower petals are white. Stamens: many. Fruit: Round like a small ping pong ball, has a strong shell and contains 1 seed. Size: fruit diameter 2.50-4 cm. The young fruit is salted for food. It can be used as a dye, oil, wood and medicine. In Bali, the old fruit is used by children to play with as marbles or small ping pong balls. In Australia, Malaysia and Indonesia (Bali) it is often planted as a shade tree. Nyamplung seed extract has potential as a natural ingredient for making cosmetics, including face masks, scrubs and sunscreens (Khery et al., 2024).

Ipomoea pes-caprae. Annual herbaceous habit with thick roots. Stem length 5-30 m, creeping, roots grow on stem segments. Stem is round, herbaceous, brownish green. Single leaves, oval-shaped, rounded edges split, 3-10 x 3-10.50 cm, thick, smooth and shiny, located crosswise. Flowers are pink - purple, concentrated at the base of the flower. Flowers are located in the leaf axils on stems that are 3-16 cm long, the crown is shaped like a trumpet / funnel, 3-5 cm long, diameter when fully open about 10 cm. Fruit is a round to slightly flat capsule with four black seeds and dense hairs. The seeds are reported to be a good remedy for stomachaches and cramps. The leaves are used for rheumatism/joint pain/aches, hemorrhoids and scabies, while the roots are used for toothache and eczema. The liquid from the stem is used to treat animal bites and stings. Pregnant women are prohibited from using this medicinal plant. The content of pharmacologically active compounds, such as alkaloids, glycosides, steroids, terpenoids, and flavonoids in plant parts are useful in traditional medicine, including inflammation, indigestion, pain, and hypertension (Akinniyi et al., 2022). *Ipomoea pes-caprae* is a source of natural antioxidants that have the potential to be developed for medicine and the pharmaceutical industry (Kumar et al., 2014).

Sesuvium portulacastrum. Habitus annual herb, creeping, many branches. Height reaches 1 m, stem is bright red, smooth and covered with roots at the joints.

Thick fleshy leaves, single type, opposite. Round elongated to lanceolate, rounded tips, size: 2.50- 7 x 0.50-1.50 cm. Small flowers, purple in color, stalked with a length of 3-15 mm and a tube length of 3 mm. The location of the flowers in the leaf axils, crown 5 lobes, length 6-9 mm, many stamens and 3-4 pistil stalks. The fruit is capsule-shaped, round and smooth, 8 mm long. The seeds do not float. Benefits: Leaves can be eaten after repeated washing and cooking. Also used as goat feed. S. portulacastrum contains tannins, steroids, terpenoids and phenols and has antioxidant activity so it has potential as an anticancer (Starun et al., 2024).

Scaevola taccada. Large shrub habit, 3–10 meters high, branched with a thickness of 1–1.5 cm with white tufts in the leaf axils. Leaves resemble succulents , 8–25 cm long, closely alternate or spiral and crowded at the end of the stem. The leaf surface is smooth, yellowish green. Flowers are grouped like fans. Each flower with white petals, 2–2.50 cm long, sometimes with purple stripes. Fruit is round, fleshy between 1–15 mm. *S. taccada* has clear calyx lobes and white fruit where the calyx lobes persist, Ripe *S. taccada fruit* changes from green to white. They can float in seawater and are propagated by ocean currents. S. taccada can be utilized in stimulating immune response because of its anti-inflammatory role (Umrah et al., 2018).

Dryosphyros sp. Tree habitus, 1–40 m high, monopodial branching, dioecious, strong and black stem, bark has a groove pattern, single leaf type, alternately arranged, no sap, no stipules, axilla on young branches or sometimes arising from old wood and lateral, flat-edged with pinnate branching, and generally the back of the leaf has twin black spots. Some members of the Diospyros genus contain antioxidants, anti-inflammatory, analgesic, antipyretic, lower blood pressure, lower blood sugar. In addition, the fruit can be consumed (Rauf et al., 2017). The flavonoids, terpenoids, and xan-thones of Diospyros are known to play antimicrobial, antioxidant, anti-inflammatory, and anticancer roles (Rauf et al., 2024).

Melastoma candidum. Shrub habit, 0.50–4 m high, many branches. Leaves are round elongated to lanceolate, the tips are tapered, size: 2-20 x 0.75-8.50 cm, thick, stiff, green to yellowish green. Pinnate leaf veins, single leaves, located crosswise. Flowers are reddish purple, flower clusters and stalks are brownish green, located at the end of the branch, in groups (each group 2-3 flowers), crown: number 4-18, diameter when fully opened 4.50-6.50 cm, petals resemble a tube with a serrated lobe shape 5. Pistil stalk: light yellow, size 8-17 mm. Fruit is a round capsule, when ripe it can be divided into several segments, dark reddish purple. The fruit is delicious to eat, the young leaves are used as vegetables/lalab. The roots, leaves and all parts of the plant can be used as medicine for digestive disorders, diarrhea, bacillary dysentery, hepatitis, mouth ulcers, vaginal discharge, nosebleeds, bleeding hemorrhoids, blood clots in blood vessels, poisoning by cassava, boils and to smooth breast milk. *Melastoma candidum* leaves contain compounds, saponins, flavonoids, phenols, tannins, steroids, and terpenoids that have potential as antibacterials *Propionibacterium acnes*.

Clerodendrum inerme. Bushy habit, creeping on the ground surface, less than 2 m high. The leaves are elliptical, elongated round, pointed at the tip, 3-4 cm long, shiny dark green (adaxial), stiff and bent inward. The arrangement is single, opposite. The flowers are bell-shaped, located in the leaf axils, in groups (3 flowers per group), crown: 5, white, there is a stalk at the bottom. The petals are green and the distance is quite far from the crown. Stamens: hang down very long when compared to the flower crown, purplish red. The fruit is oval, green to brown, shiny, fleshy, fruit diameter 7-10 mm. Clerodendrum is known to have many roles in the medical world. Extracts from the Clerodendrum genus have anti-inflammatory, antioxidant, antihypertensive, anticancer, antimicrobial, anti-diarrhea, liver-protecting, blood sugar-lowering and fat-lowering, memory-enhancing and neuroprotective activities (Wang et al., 2018).

Pandanus tectorius. Tree habitus, broadly branched, reaching 6 m in height. Supporting root system with aerial roots from branches. Leaves are green, stiff, waxy at the tip, tapering at the tip. Leaf veins are parallel. Leaves appear in clusters at the ends of twigs, in 3 spirally arranged rows, seated, with the base hugging the stem. Leaf size 50 - 200 x 3-9 cm. Red flowers, located at the tip. Fruit like pineapple. Benefits: can be used as a hedge plant. The flowers are used for fragrances and decorations at weddings. Methanol extract of sea pandanus contains phenolic compounds, flavonoids, saponins and steroids that can counter the free radicals (Oksal & Artikel, 2023), so that it can be utilized as an ingredient of cosmetic products (Setiawan et al., 2024).

Hibiscus tiliaceus. Tree habit, up to 15 m tall. Smooth bark, with grayish brown spots. The leaves are thinner than *Thespesia populnea* leaves, heart-shaped, pointed at the ends, size: 7.50-15 x 7.50-14.50 cm, the abaxial surface has fine hairs that are slightly white in color. Single leaves, crossed. The shape of the flower resembles a bell, light yellow, the middle part of the base with an orange/dark color. Located in the leaf axil, the crown is yellow, 5-7 cm in diameter, serrated petals. Style 5 not fused, the stigma is brownish purple. The fruit is divided into 5 parts, the seeds are typically hairy, the fruit diameter is 2 cm. Planted as a shade tree in parks. The roots are used as a medicine for fever. The wood fibers are used as rope. The leaves have potential as animal feed (Suhubdy et al., 2023). The wood is used as a material for making boat interiors (Lombok). Bima

people utilize its wood as a material for building traditional houses (Yusmerianti et al., 2023).

Thespesia populnea. Tree habit, 2-10 m high. The leaves are thick, smooth surface. Heart-shaped with pointed tips with a size of 7-24 x 5-16 cm, single leaves with a crossed position. The flowers are bell-shaped, light yellow, the middle base is orange/dark, the style is fused, yellow with a blunt tip. The fruit is like a ball and segmented, 2.50-4.50 cm in diameter, there are 3-4 seeds in each space/segment of the fruit which is densely covered by short hairs. The bark is used as a fiber material. Leaves and fruit are used as medicine. *T. populnea* extract has anti-bacterial and anti-fungal activities (Chandran & Nair, 2014). The leaf extract contains antioxidants that have anticancer potential (Dass et al., 2022).

Conclusion

The results of mangrove identification in Karimunjawa National Park found 14 families consisting of 38 mangrove species. Among the 38 species, 24 species are true mangroves, while the other 14 species are associated with mangroves.

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Conflicts of Interest
No conflict of interest.

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