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Species diversity of aquatic plants in Anggerper Swamp in Merauke District, South Papua Province, Indonesia

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Abstract. *Merly SL, Pangaribuan RD, Kando YE, Pane LR, Tuhumena JR. 2024. Species diversity of aquatic plants in Anggerper Swamp in Merauke District, South Papua Province, Indonesia. Biodiversitas 25: 4712-4721.* The aquatic plants in Anggerper Swamp, Merauke District, South Papua Province, Indonesia have never been studied, causing the development of their potential is still insufficient. This research aimed to identify species diversity of aquatic plants, through a species identification approach, Shannon-Weaver Species Diversity Index (H'), Evenness Index (E), Dominance Index (D), and Important Value Index (IVI). Two methods used in this study are cruising survey and purposive sampling method using transect quadrant. There are two research stations with 120 quadrants measuring 1 x 1m. This study successfully identified 14 aquatic plant species from 9 families. Moreover, the majority of these aquatic plants are known as emergent and introduced plants. In Station I, total individuals reached 6,531 with 10 species and in Station II reached 2,576 individuals with 12 species. The diversity index for both stations tends to moderate, 1.92 in Station I and 2.53 in Station II, successively. The evenness index is stable with high uniformity, where Station I is 0.83 and Station II is 0.95, respectively. The dominance index for both stations indicates low dominance (0.21 in Station I and 0.10 in Station II). The highest aquatic plants' IVI belongs to *Nymphaea nouchali* (65.66%) and *Urochloa mutica* (63.16%).

Keywords: Anggerper swamp, aquatic plants, community structure, Important Value Index, Merauke

INTRODUCTION

Aquatic habitat in tropical wetlands gives great ecological importance, especially inland freshwater like swamps (Gopal 2016). As a part of wetlands, swamps are known as freshwater ecosystems with the potential for diverse biological resources. Swamps have distinctive characteristics, namely the difference in water levels during the dry and rainy seasons, and are also found in river basins. Economically, the existence of swamps is necessary for the needs of humans living nearby because, in swamp waters, there are various species of fish and aquatic plants that are useful for humans (Huang et al. 2020). Human activities easily disturb swamp ecosystems; returning to their original condition will not be easy once disturbed. One of these factors causes changes to the structure of the vegetation that grows within it (Short et al. 2016; Zhang et al. 2017; Huang et al. 2020).

The presence of aquatic plants in waters can create high water primary productivity, produce a high diversity of aquatic biota, and be important for the swamp ecosystem (Gettys et al. 2014; Paramitha and Kurniawan 2017; Ceschin et al. 2021). Aquatic plants considered as indicators of environmental qualities, have numerous benefits and roles in water. They play an important role in maintaining the structure and function of swamp ecosystems and provide habitat for many organisms, and indirectly benefit fish larvae by providing a place to attach substrates such as periphyton (Gettys et al. 2014; Du et al. 2017). Aquatic plants also produce oxygen during the photosynthesis process, providing aesthetic value to swamps, able to absorb heavy metal elements to reduce pollution (Souri 2020; Ali et al. 2022), potential and effectiveness for phytoremediation (Rezania et al. 2016; Muthukumaran 2022).

Each community's ability to assign the plant's composition in an ecosystem depends on every individual's pattern of adjustment to environmental factors in the ecosystem. Henceforth, it is necessary to research community structure to determine the relationship between an organism's existence and environmental factors. Community structure is a concept that studies the arrangement and composition of species and their abundance in a community. Research on the aquatic plant has been widely carried out in some areas in Indonesia, such as several priority lakes for conservation (Kurniawan and Paramita 2020), upper Bengawan Solo River, Central Java (Pramono et al. 2024), and Mayo Swamp, South Papua (Merly et al. 2023). Therefore, a similar study to identify the biodiversity of aquatic plants in the Merauke District, South Papua Province was still lacking and limited. Anggerper Swamp is an area with unique and potential biological resources and is supported by natural forests with the characteristics of semi-enclosed waters. There is no information yet about the diversity of aquatic plants in this area, which may differ and have unique characteristics compared to other areas in Indonesia.

The abundant presence of aquatic plants in Anggerper Swamp makes a promising natural potential; supported by water conditions that are still beautiful and there are no visible signs of pollution, resulting in a high diversity of aquatic plant species. Nevertheless, some fisherman inadvertently uses unsustainable local fishing activities, such as electrofishing, which could significantly change the Anggerper Swamp ecosystem. The increasing population in Merauke District currently affects the demand for fisheries products, including inland fishery (BPS 2023). Based on the previous explanation with additional early survey information, we have concisely stated that direct utilization of community activities to natural resources will cause environmental pressure. Considering that natural resources like aquatic plants in this area have not been identified and are still haunted by current threats, this study urgently needs to preserve and utilize them sustainably. Through this research, we will discover and identify the species, analyze the community structure which consists of diversity index, evenness index, dominance index, and finally calculate the important index value of aquatic plants in Anggerper Swamp.

MATERIALS AND METHODS

Study area

Anggerper Swamp is located in Jagebob Sub-district, Merauke District, South Papua Province, Indonesia. Jagebob Sub-district has a total area reach 1,369.37 km^2 or 3.04% of the total area of Merauke District (BPS 2023). The geographical site of the research location in Anggerper Swamp is 140°44'10"-140°47'00"E and 08°04'02"-08°07'04"S. This location borders Angger Permegi Village in the north, Trans Papua Road in the west, Maro River in the east, and Wenda Sari village in the south. The sampling site in Anggerper Swamp is divided into 2 stations (Figures 1 and 2). Hereinafter, the sampling was done twice in September and October 2022.

Henceforth, the information on each sampling location including the data on environmental parameters including temperature, density, depth, and pH in both stations is presented in Table 1.

Table 1. Detail location and environmental parameters measurements

Station	Location	Coordinate	Characteristics	Environmental parameters			
				Temperature (°C)	Density (cm)	Depth (cm)	pH
I	Angger Permegi Village, Jagebob Sub-district	140°45'50.21"E-08°05'0.29"S	Semi-enclosed water area, nearby residential	30.01-33.3	30-40	30-50	5.1-5.5
II	Angger Permegi Village, Jagebob Sub-district	140°46'2.97"E-08°05'50.19"S	Open water area, far from residential, less community activities	28.00-33.71	30-70	70-150	5.0-6.3

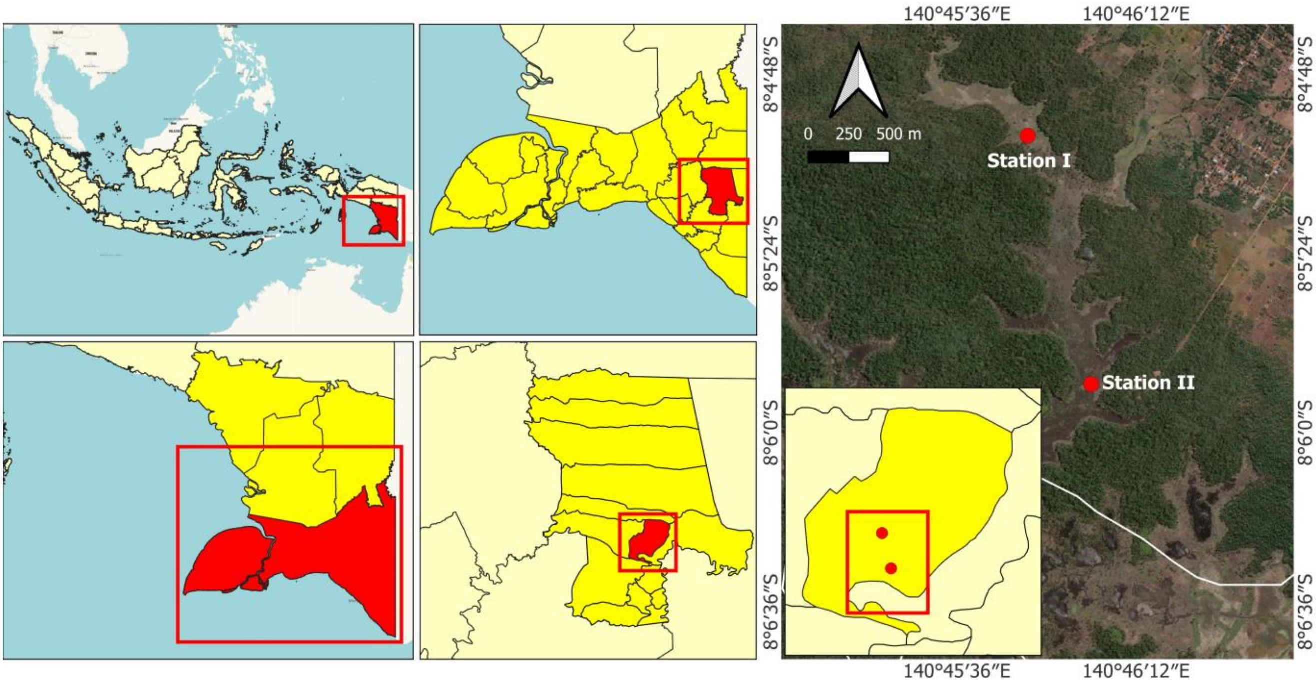

Figure 1. Location of Stations I and II in the Anggerper Swamp, Jagebob Sub-district, Merauke District, South Papua, Indonesia

Figure 2. Research location conditions in Anggerper Swamp, Merauke District, Indonesia: A. Station I; B. Station II

Procedures

This research used a combination of cruising survey and purposive sampling (Pramono et al. 2024) with approach of transect quadrant for collecting sample. The sampling activity began with 10 × 10 m^2 transect sets totaling 6 transects at two stations. Then, inside the 10 × 10 m^2 transect, we have placed a 1 × 1 m^2 quadrant. Transects and quadrants were placed randomly, referring to both methods. So, there will be 24 plots measuring 10 × 10 m^2 and 120 quadrants of 1 × 1 m^2. The short sampling time was able to answer the research objectives with the large number of quadrants placed at the research location. Then, samples began to be collected after calculating the species and coverage of aquatic plants in the quadrant.

The aquatic plant samples are put into a labeled plastic bag and placed in a coolbox to preserve the sample. Identification and analysis data were held in the Aquatic Resources Management Laboratory, Faculty of Agriculture University of Musamus. The identification of samples was using identification books, such as Aquatic Weeds of Southeast Asia (Pancho and Soerjani 1978), Plant Taxonomy (Spermatophyta) (Tjitrosoepomo 2007), The World of Still Water (Gibbons 1986), scientific articles (Lisdayanti et al. 2016; Du et al. 2017; Merly et al. 2023), and websites, such as Plantamor (https://plantamor.com/species/search), Plants of the World Online (https://powo.science.kew.org/), and Global Biodiversity Information Facility (https://www.gbif.org/).

Data analysis

Community structure

Several indices were used for analyzing community structure, such as Shannon-Weaver Diversity Index (H'), Evenness Index (E), and Dominancy (D) using the following formula described by Shannon and Weaver (1949) and Huang et al. (2020).

Diversity Index (H') shows the level of heterogeneity of species and is described as follows:

$$H' = -\sum_{i=1}^{s} Pi \ln Pi, \text{ with } Pi = ni / N$$

Where :
H' : Diversity Index
ni : Number of individuals of i-species
N : Total number of individuals
ln : Natural logarithms

The diversity indices are distributed into 3 categories as presented in Table 2.

Evenness Index or balance is the individual composition of each species found in a community, and is calculated using the following formula as follows:

$$E = \frac{H'}{Hmax}$$

Where :
E : Evenness Index
H' : Diversity Index
Hmax : Number of species discovered

Evenness Index is varied from 0 to 1.0 (Table 3). Dominance Index determines the level of species dominating an environment and is measured using a formula as follows:

$$C = \sum (pi)^2$$

Where :
C : Dominance Index
pi : Proportion of species-i to the total individuals

There are three categories to determine the dominance levels as presented in Table 4.

Table 2. The Diversity Index (H') criteria

Value	Category
If H'<1	Low species
If 1<H'<3	Moderate species
If H'>3	High species

Table 3. The Evenness Index (E) criteria

Value	Category
0<E≤0.5	Stress condition and evenness less
0.5<E≤0.75	Conditions are less stable and evenness moderate
0.75<E≤1.00	Stable condition and evenness high

Table 4. The Dominance Index (C) criteria

Value	Category
0<C≤0.5	Low dominance
0.5 C≤0.75	Moderate dominance
0.75<C≤1.00	High dominance

Important Value Index (IVI)

The Important Value Index (IVI) is the accumulative of Relative Density species (RDi), Relative Frequency of species (RFi), and Relative Cover of species (RCi) (Brower et al. 1990; English et al. 1994). IVI is calculated using a formula as follows:

IVI = RDi + RFi + RCi

The importance of a species ranges from 0 to 300% (English et al. 1994). This important value provides an overview of the influence or role of aquatic plant species in the aquatic plant community.

Species Density (Di) and Relative Density (RDi)

Species Density (Di) is the number of stands of i-species in a unit area and relative density is the comparison between number of i-species divided by the total individuals. Determination of specific density using the formula described by English et al. (1994) as follows:

$$\mathrm{Di} = \frac{\mathrm{Ni}}{\mathrm{A}}$$

Where :
Di : Density of i-species
Ni : Total number of individuals of i-species (ind)
A : Total sampling area (m^2)

$$\mathrm{RDi} = \frac{\mathrm{Ni}}{\sum \mathrm{n}} \times 100\%$$

Where :
RDi : Relative density (%)
Ni : Amount of i-species (individuals)
∑n : Total all individuals (individuals)

Species Frequency (Fi) and Relative Frequency (RFi)

Frequency (Fi) is an opportunity to find i-species in all sampling transect sites. Meanwhile, Relative Frequency (RFi) means the comparison between species Frequency (Fi) and total frequency of all species (∑F). Both data were analyzed using a formula described by English et al. (1994) as follows:

$$\mathrm{Fi} = \frac{\mathrm{pi}}{\sum \mathrm{n}}$$

Where :
Fi : Species frequency of i-species
pi : Total of quadrants where the sample exists
∑n : Total quadrant

$$\mathrm{RFi} = \frac{\mathrm{Fi}}{\sum \mathrm{F}} \times 100\%$$

Where :
RFi : Relative Frequency (%)
Fi : Frequency of i-species (individuals)
∑F : Total amount of all species (individuals)

Species Coverage (Ci) and Relative Coverage (RCi)

Coverage (Ci) is to measure the cover percentage of i-species in every sampling site, with the formula described by Brower et al. (1990) as follows:

$$\mathrm{Ci} = \sum \left(\frac{\mathrm{Mi} \times \mathrm{fi}}{\mathrm{F}}\right)$$

Where :
Ci : Vegetation cover value
Mi : Mid class value of i-species (individuals)
fi : Frequency occurrence of i-species class coverage
∑f : Total amount frequency of all classes

Furthermore, Relative Coverage (RCi) means percent Coverage of each species (Ci) divided by the total percentage of all species (English et al. 1994) as follows:

$$\mathrm{RCi} = \frac{\mathrm{Ci}}{\sum \mathrm{Ci}} \times 100\%$$

Where :
RCi : Relative Coverage (%)
Ci : Coverage of i-species
∑Ci : Total coverage of all species

RESULTS AND DISCUSSION

Species diversity

Fourteen species from 9 families of aquatic plants were identified in Anggerper Swamp (Table 5; Figure 3). Some aquatic plants are found in huge numbers of individuals, some are less, even absent in other station sites. In Station I with 10 species with total sample reached 6,531 individuals, meanwhile, in Station II with 12 species reached 2,576 individuals.

Community structure

The aquatic plant diversity index in Anggerper Swamp in Station I and II are 1.92 and 2.53, respectively (Table 6). The Diversity Index value (H') at Station I and Station II is 1.92 and 2.53, respectively. According to Shanon-Weaver criteria (Table 2), the Diversity Index (H') at both stations belongs to medium category. Moreover, the Evenness Index (E) values obtained at both stations in high category which means the composition of individuals in a community in a stable condition. The Evenness Index (E) value at Station I and Station II is 0.83 and 0.95, respectively. Uniformity or balance is the composition of individuals in a community. Henceforth, the Dominance Index (C) value for Station I and Station II is 0.21 and 0.10, respectively and categirezed as low. It means that both stations do not contain dominant aquatic plants, because the dominance index is categorized as low dominance (Table 4).

Important Value Index (IVI)

The important value index measurements of the aquatic plants in Anggerper Swamp ecosystem consist of three components, i.e. relative density, relative frequency, and relative coverage (Table 7). Those three elements combine to get the amount of the Important Index Value. The aquatic plant that we have found showing the highest numbers in density, frequency, and coverage belongs to *Urochloa mutica* (Forssk.) T.Q.Nguyen. Whether the absolute density and relative density reach 31.25 ind./m^2 and 41.19%, respectively. The same trend is shown with the frequency (0.45), relative frequency (15.07%), coverage (4.65), and relative coverage (6.90%). The high numbers of these three index become the reason the *U. mutica* is the species with the highest important value compared to the 13 aquatic species found in the Anggerper Swamp. Conversely, species with the lowest numbers of density, frequency, and coverage including IVI belong to *Eriocaulon cinereum* R.Br. where the relative density is 0.04%, relative frequency 0.27%, relative coverage 0.12, and IVI 0.44%.

Discussion

The 14 species of aquatic plants in Anggerper Swamp at Jagebob Sub-district, Merauke District reveal higher diversity than Mayo Swamp, Kurik District which successfully identified 4 species (Merly et al. 2023). Nevertheless, this result is lower than several swamps in South Kalimantan, such as Hulu Sungai Utara, Tanah Laut and Barito Kuala Districts which recorded 26 species of aquatic plants (Dharmono et al. 2022), and also in Bengawan Solo River, Central and East Java with the total of 23 species (Pramono et al. 2024). The limited of stations and research areas, compared with the same aquatic plant research in other areas like Kalimantan and Java, become the reason for the lack of number of species found in this study. Besides, the dry season during research creates other disadvantages for aquatic plant diversity due to drops in water levels and increases in water temperature (Gettys et al. 2014). BPS (2023) mentioned that number of precipitation in Merauke District from August until November 2023 between 6.50 and 106.10 mm with an average of 3-9 rain days, and average duration of sunshine reach 6.06-7.25 hours a day. Nevertheless, the current weather is unpredictable; suddenly, rain with high intensity can also affect aquatic plants. In addition, Campbell et al. (1988) explain that rain can affect acidity levels and cause several diseases in plants. Compared with the measurement of water acidity in this area we found the pH under 7 which means the water body is acid for both stations.

Most species found are typical emergent plants and 4 species out of 14 species are known as native to the swamp ecosystem in this area. Emergent plants have possibilities to obtain nutrients from water column and substrate, because the plants are rooted in the bottom with their leaves floating on the water's surface (Pierzchała and Sierka 2020). Another advantage of emergent vegetation was proven the capability to maintain the clarity of water, and even increase the clarity of water in mining subsidence reservoirs in Karvina, Czechia (Pierzchała and Sierka 2020). Based on the calculation of the number of each species, it identified that *U. mutica* and *Azolla pinnata* R.Br. are the two most species with high numbers in their presence. The number of individuals for *U. mutica* and *A. pinnata* reached 3,751 individuals and 2,095 individuals, respectively.

U. mutica (para grass) is an invasive species and is widespread on moonsonal wetlands in northern Australia including in the area of Kakadu National Park (KNP). Furthermore, Boyden (2015) defined distribution patterns of para grass is along a depth habitat gradient. *U. mutica* is distributed into two habitats freshwater and estuarine habitats and is known as semi-aquatic species which aggressively invades lowland areas, such as wetlands, streams, estuaries including low energy habitats throughout tropical regions (Sakihara et al. 2017). The ability to tolerate various environmental parameters, including salinity, creates this species that can survive and proliferate even in unstable ecosystems. Therefore, as a part of submerged plants, it usually less productive than emergent and floating plants (Gettys et al. 2014). The next species found in abundant numbers is *A. pinnata* as known as floating plants or water fern. It is distributed in warm tropical region and naturally occurs in freshwater bodies. The species is easily found in a natural pond at the alluvial site and sensitive to heat and light. Moreover, Jama et al. (2023) illustrate that function of *Azolla* as an effective fertilizer, they also can mineralize Nitrogen (N) more rapidly compared to compost.

Table 6. Value of diversity, evenness, and dominance index

Station	Diversity Index (H')	Evenness Index (E)	Dominance Index (C)
I	1.92 (moderate)	0.83 (High)	0.21 (Low)
II	2.53 (moderate)	0.95 (High)	0.10 (Low)

Table 5. Species diversity of aquatic plants and total individuals per station

Family	Species	Growth type	Status*	Station	
				I (individuals)	II (Individuals)
Salviniaceae	*Azolla pinnata* R.Br.	free-floating	introduced	2,089	6
Poaceae	*Urochloa mutica* (Forssk.) T.Q.Nguyen	emergent	introduced	3,036	715
Poaceae	*Catabrosa aquatica* (L.) P.Beauv.	emergent	introduced	597	85
Cyperaceae	*Cyperus laevigatus* L.	emergent	introduced	65	420
Cyperaceae	*Cyperus polystachyos* Rottb.	emergent	native	0	143
Cyperaceae	*Cyperus rotundus* L.	emergent	introduced	16	441
Cyperaceae	*Cyperus squarrosus* L.	emergent	introduced	0	93
Cyperaceae	*Eleocharis parvula* (Roem. & Schult) Link ex Bluff, Nees & Schauer	emergent	introduced	0	94
Eriocaulaceae	*Eriocaulon cinereum* R.Br.	emergent	introduced	0	4
Onagraceae	*Ludwigia erecta* (L.) H.Hara	emergent	introduced	61	18
Nymphaeaceae	*Nymphaea nouchali* Burm.fil.	emergent	native	54	395
Menyanthaceae	*Nymphoides indica* (L.) Kuntze	emergent	native	572	0
Philydraceae	*Philydrum lanuginosum* Banks & Sol. ex Gaertn.	emergent	native	10	0
Lentibulariaceae	*Utricularia australis* R.Br.	emergent	introduced	31	162
Total				6,531	2,576

Note: *https://powo.science.kew.org/

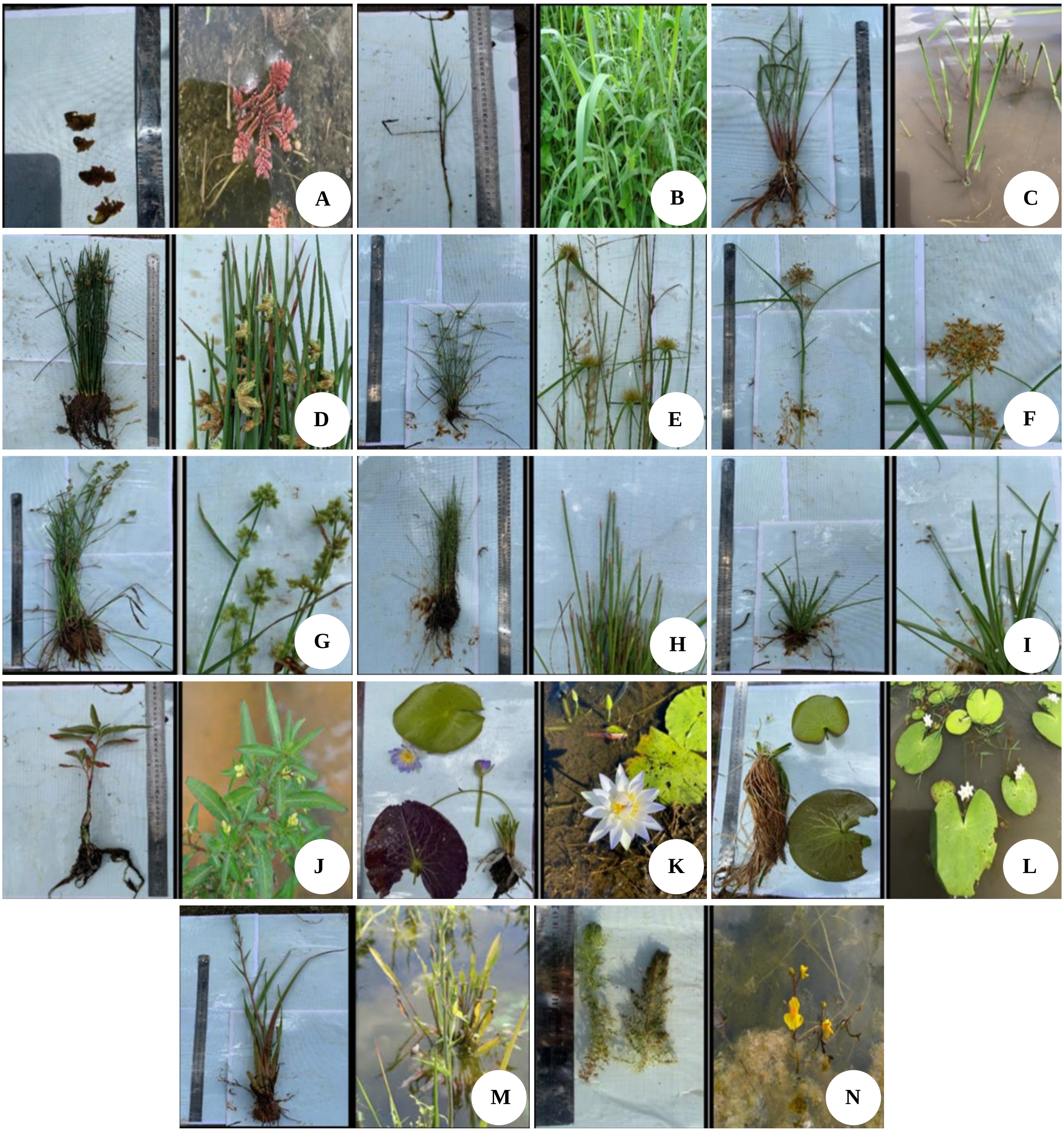

Figure 3. Species diversity of aquatic plants in Anggerper Swamp, Merauke District, Indonesia: A. *Azolla pinata*; B. *Urochloa mutica*; C. *Catabrosa aquatica*; D. *Cyperus laevigatus*; E. *Cyperus polystachyos*; F. *Cyperus rotundus*; G. *Cyperus squarrosus*; H. *Eleocharis parvula*; I. *Eriocaulon cinereum*; J. *Ludwigia erecta*; K. *Nymphoides nouchali*; L. *Nymphoides indica*; M. *Philydrum lanugunosum*; N. *Utricularia australis*

Environmental parameters play an important role to affect the success of certain species to grow and develop rapidly. Li et al. (2017) mentioned the major factors influencing water quality and aquatic plant growth are areas and seasons. Environmental parameters for both stations showed ideal conditions for the growth of aquatic plants. Nevertheless, some of parameters in Station II are more varied compared with Station I. This condition resulting the diversity of species in Station II is higher than in Station I. There are 12 species collected in Station II, while in Station I just found 10 species. However, the total individuals show different numbers with total samples of 6,531 individuals in Station I from 10 species and 2,576 individuals from 12 species in Station II. Human activities also affect the presence and abundance of aquatic plants. Station II with tress and less trespassing activities of the local community surrounding the ecosystem has a water depth of 70-150 cm, temperature 28.0°-33.7°C, pH 5.0 to 6.3, and light penetration (water clarity) between 30 and 70 cm. These conditions support the submerged aquatic plants at Station II to have access to photosynthesis, because light penetrates the hadal area in the swamp. *U. mutica* is massive in Station II reaching 715 individuals or 27.76% from total individuals in this station. Meanwhile, in Station I with a high number of human activities and supported by environmental parameters like water depth of 30-50 cm, temperature from 30.01° to 33.3°C, pH from 5.1 to 5.5, and light penetration (water clarity) reaching 30 to 40 cm. This condition resulted in the number of *U. mutica* and *A. pinnata* found abundant in Station I, 2.089 individuals and 3,036 individuals, respectively. *A. pinnata* is less in Station II with 6 individuals, this is because in the Station II surroundings with trees and the surface experience shading by the leaves and inhibit *Azolla* to growing rapidly.

The diversity index compares the number of species and the total individuals in a community. There are possibilities of missing certain species while collecting samples. Initially, this research have 3 stations, but one Station Is prohibited by the local government and villagers to access caused of the recent discovery of crocodiles at the third station. We have decided to eliminate the research area into two stations, but increasing the number of quadrants. The diversity index determines the state of succession or community stability (Heriyanto and Subiandono 2016). The richness of aquatic plants is related to productivity, such as light attenuation, nutrient concentration, water velocity, pH, boat traffic, and water level fluctuation (Eisemann et al. 2021). Furthermore, Bezabih and Mosissa (2017) explained that aquatic plant diversity can be influenced by many factors, such as hydrological alteration, habitat loss, over-grazing, high human population pressure, unregulated over-utilization, water diversion for agricultural intensification, global climate change, and inappropriate economic development policy. The excessive utilization can be caused by regulations and uncontrolled supervision from various parties like the government regarding natural resource utilization procedures, such asperiods, extraction/ harvesting methods, and limits on natural resources amount that can be taken including plant utilization in Anggerper swamp. The common usage of aquatic plants in this area is still modest such as for livestock feed. Initially, further action for preserving the biodiversity of aquatic plants taken by authorized could lead to wise utilization and protection, and ultimately the community certainly will experience the positive impact of economic potential by those actions, such as increasing fish production, tourist and research destinations, and more possibilities.

The differences in diversity index values at each research station are due to aquatic plant species and the varying numbers. Variations and abundance of a species in each observation area will influence the high and low values of the diversity index. Refers to diversity criteria (Table 6), the diversity index for both stations is categorized as moderate (1.92 and 2.53). Zhou et al. (2022) explained that the Diversity Index (H') is diversity that shows little or the number of individuals and species found in a body of water, meaning that the greater the number of species and the number of individuals for each type of organism, the higher the diversity index value, the diversity index also shows balance in the distribution of individuals for each type. Even though it showed the same category, Station II has a higher value index than Station I.

Table 7. Diagnostic of Important Value Index (IVI)

Species	Density		Frequency		Coverage		IVI (%)
	Absolut density (ind/m^2)	Relatives density (%)	Absolut frequency	Relatives frequency (%)	Absolut coverage	Relatives coverage (%)	
Azolla pinnata R.Br.	17.45	23.00	0.33	10.96	1.87	2.78	36.75
Urochloa mutica (Forssk.) T.Q.Nguyen	31.25	41.19	0.45	15.07	4.65	6.90	63.16
Catabrosa aquatica (L.) P.Beauv.	5.68	7.49	0.29	9.59	3.38	5.02	22.10
Cyperus laevigatus L.	4.04	5.33	0.07	2.47	0.76	1.14	8.93
Cyperus polystachyos Rottb.	1.19	1.57	0.05	1.64	0.58	0.87	4.08
Cyperus rotundus L.	3.80	5.02	0.22	7.40	4.64	6.89	19.30
Cyperus squarrosus L.	0.77	1.02	0.10	3.29	0.58	0.87	5.17
Eriocaulon cinereum R.Br.	0.03	0.04	0.01	0.27	0.08	0.12	0.44
Eleocharis parvula (Roem. & Schult)	0.78	1.03	0.04	1.37	2.00	2.97	5.37
Ludwigia erecta (L.) H.Hara	0.65	0.87	0.12	4.11	0.79	1.17	6.15
Nymphaea nouchali Burm.fil.	3.74	4.93	0.71	23.56	25.02	37.17	65.66
Nymphoides indica (L.) Kuntze	4.76	6.28	0.41	13.70	18.44	27.36	47.34
Philydrum lanuginosum Banks & Sol. Ex Gaertn.	0.08	0.11	0.04	1.37	0.79	1.17	2.65
Utrikularia australis R.Br.	1.60	2.12	0.15	5.21	3.75	5.56	12.89

The relationship between diversity indices and environmental variables to detect the ecological variables that drive aquatic plant diversity (Zhou et al. 2022). Genetic and environmental factors generally determine differences in plant types or diversity. Environmental factors will change according to environmental demands, where human influence will be smaller, so that if environmental factors change it will allow species diversity to grow and at the same time survive. This is interesting because any change in the environment can affect plant species. The decreasing trend in aquatic plant diversity can reduce ecosystem function caused by anthropogenic activities (Huang et al. 2020). Increasing the altitude also reduces aquatic plants' taxonomic, phylogenetic, and functional diversity. Therefore, prevention is necessary to control the invasion of introduced aquatic plants like *U. mutica*.

Uniformity means the composition of individuals in a community. Huang et al. (2020) divided uniformity or Eveness into three categories there are: Less evenness (stress condition if the value is $0<E\leq0.5$), continues with moderate evenness (a less stable condition, whereas if the value is $0.5<E\leq0.75$), and lastly the condition is stable (high uniformity if $0.75<E\leq1{,}0$). So, distribution of individuals in Anggerper Swamp is included in the high Evenness Index (E) category, or there are no dominant species with 0.83 in Station I and 0.93 in Station II. Even though, only a few species of aquatic plants were found, the abundance of individuals from each species represented is distributed evenly in the community and there is no dominant species. This result supports Wohlgemuth et al. (2016) that the most dominant species exerts a disproportionate influence on functioning at low levels of evenness. On the other hand, if changes occur based on biomass distribution and the emphasis on species-environment interactions becomes more important in regulating system functionality as equity increases, then the diversity index describes a community's stability level (Lisdayanti et al. 2016). There is no dominant species according to the result of this study. If the dominance index is high, dominance is concentrated or found in one species, but if the diversity index value is low, dominance is concentrated in several species. The dominant aquatic plants can caused by changes from native plants to invasive plants (Gao et al. 2017; Zhang et al. 2017; Huang et al. 2020). the value of dominance index are 0.21 and 0.10 in Stations I and II, respectively and classified as low dominance.

These three index values express community structure, where a community is said to have high species diversity, if the proportion between species as a whole is the same. So, if several species in a community have great abundance or dominance, then the diversity and evenness will be low. Through community structure, the species richness of aquatic plants and the total diversity of the contribution can provide precious information to protect species threatened at multiple scales of aquatic plants worldwide (Bolpagni et al. 2018). Wassens et al. (2017) mentioned that plant community composition and structure changed between pre and post-dry stages. This means the temperature influences changes of a significant reduction in the percentage cover of aquatic species and the loss of formerly dominant aquatic species.

Valladares et al. (2016) mentioned various factors related to plant life, such as nutrition in aquatic and terrestrial habitats, temperature variation, light intensity, and water movements. Water movements have particularly drastic consequences on plant density and leading to mechanical solid strains on plant tissues. Besides, several abiotic factors, like substrate anoxia, inorganic carbon availability, and temperature, significantly influence aquatic plants. Additionally, the potential number of water bodies available for colonization is a key factor in driving the geographical distribution of aquatic plants (Alahuhta et al. 2017). These informations provide a deeper understanding of the complex interactions within aquatic ecosystems.

The IVI is used to determine the dominance of one species over other species in a body of water. Ara and Jamil (2020) stated that the important role of aquatic plant vegetation in an ecosystem can be proven by adding up the relative density, relative frequency, and relative cover. Based on the analysis of the data obtained, the highest Relative Density (RDi) in the waters of Rawa Anggerper is para grass (*U. mutica*) at 41.19% and the lowest is gong grass (*E. cinereum*) at 0.04%. Para grass is known to be a species of aquatic plant with morphological characteristics in the form of small stems, and short rhizomes, but can tolerate environments with acidic soil. This is because para grass adapts to various environmental conditions, including in areas that do not contain enough water or even without water (Sumolang et al. 2020). Para grass previously known as *Brachiaria mutica* (Forssk.) Stapf (Vorontsova 2022). At the research location, the pH measured ranged from 5 to 6; according to Sema (2019), para grass is an aquatic plant that can grow in rainfall of 1000 mm/year with a fairly wide pH tolerance ranging from 5-7. This plant is known as a native species in Sahara to Angola, North Africa until Syria and SW. Arabian Peninsula and resistant to drought for 6 months and cold weather. So, para grass has the largest number of individuals and is the species with the highest Relative Density (RDi) because the environmental parameters are ideal for its growth.

Water lily (*Nymphaea nouchali* Burm.fil.) had the highest RFi value of 23.56%. In comparison, the lowest was gong grass (*E. cinerum*) at 0.27%. This is because water lily can be found in 86 quadrants out of 120 quadrants, and the depths range from 50 to 120 cm. Khan et al. (2019) reported water lily could live at 30 to 120 cm depth. Meanwhile, the temperature in the waters of Rawa Anggerper is around 28-33.3°C; this is aligned with Khan et al. (2019) that water lily can be found at temperatures ranging from 28-30°C. So, water lily has a wide vertical and horizontal distribution. Prakash (2021) mentioned that the climate change stresses exert a complex pressure on aquatic biodiversity and natural aquatic resources and, finally, may alter aquatic organism metabolism and physiology. It means the water temperature variation can affect the biodiversity in wetlands like the frequency of aquatic plants in Anggerper Swamp.

In line with RFi, the RCi of water lily has the highest RCi value of 37.17%. In comparison, the lowest is gong grass of 0.12%. The high percentage of cover of the water lily because it has a fairly wide cross-sectional leaf size.

Even though the number of individuals is only small, of 395 individuals, it has the highest relative cover compared to other species. The results of observations and analysis results at the Rawa Anggerper showed that 2 species of aquatic plants have important index values above the average compared to other species, namely water lily at 65.66% and para grass at 63.16 %. These species had a high percentage, causing them to have broad leaves despite low numbers of individuals. So, these two species of aquatic plants are aquatic plants that represent the characteristics of the Anggerper Swamp ecosystem. Furthermore, both aquatic plant species create shade for organisms that live under the canopy, where the shade of aquatic plants plays a significant role in mitigating negative effects of climate change and, at the same time, controls the temperature, including humidity, under the canopy (Valladares et al. 2016).

The species with the higher numbers of IVI are *N. nouchali* (65,66%), *U. mutica* (63,16%), *N. indica* (47.34%), and *A. pinnata* (36,75%). Meanwhile, the lowest IVI is *E. cinereum* (0.44%). *N. nouchali* also known as Chinese water lily is distributed in tropical to temperate regions (Li et al. 2019; Zhang et al. 2023). Water lily found in Anggerper Swamp have purple colors. Guruge et al. (2017) and Yakandawala et al (2017) describe water lily having leaves with blade glossy bright green above dark purple blotches and abaxial surface purple to deep blue-violet, even though water lilies in some areas like Sri Lanka have blue, pink, white and violet flowers. This species has a large distribution area, like swamps, marshes, and rice fields. *U. mutica* responds better when impacted by metal than other aquatic plants found in Anggerper Swamp. Still, there is less tolerance and bioaccumulation than *Sesbania sesban* (L.) Merr., some of these species' adaptation is reduced shoot dry biomass, root dry biomass, total chlorophylls and carotenoid content (Patra et al. 2020; Ullah et al. 2020). *U. mutica* is known for salt resistance and fodder purpose (Ullah et al. 2021). *Nymphoides indica* (L.) Kuntze is a pretty plant, fast growing, perennial water plant, has a short, thick stem which is rooted in the mud at the bottom of swamp (Khadka and Koirala 2021). This species has large whorled leaves, ovate-orbicular, cauline and floating, creating a high cover percentage, and eventually influencing the IVI value.

These fourth species of aquatic plants adapt well to various environmental pressures, including pollution. Nevertheless, the species *E. cinereum* in this research's lowest IVI, known to be widely distributed in America, Africa, and Asia, with the richness centers in the tropics area. This species grows in wetlands, shallow rivers, and streams with adaptive morphological apparent of elongated submerged stems. There is no information yet about the distribution of this species in Indonesia, but listed as the Australian species (Larridon et al. 2019). Previous research of DNA barcoding in South Papua Province, shows there are similarities of species in Indonesia and Australia reaching 90% (Merly and Saleky 2021).

In conclusion, 14 species from 9 families were identified in the aquatic ecosystem at Anggerper Swamp, Merauke. In Station I was found 10 species with 6,531 individuals, whereas Station II was found 12 species with 2,576 individuals. The diversity index at the two research stations categorized as moderate with 1.92 in Station I and 2.53 in Station II. Therefore, the Evenness Index (E) is categorized as in stable condition with high uniformity, where Station I is 0.83 and Station II is 0.95, respectively. The Dominance Index (D) shows that at Station I is 0.21, and at Station II is 0.10, indicating that the dominance of aquatic plants in Anggerper Swamp is categorized as low. The highest IVI of aquatic plants belongs to *N. nouchali* with 65.66% and *U. mutica* with 63.16%.

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