JPPIPA 9(1) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Characteristics of Sentigi (*Pemphis acidula*) as Environmental Bioindicators of Mangrove Conservation in the Regional Marine Conservation Area Gili Sulat East Lombok, Indonesia

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Received: November 28, 2022
Revised: December 27, 2022
Accepted: January 18, 2023
Published: January 31, 2023

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DOI: 10.29303/jppipa.v9i1.2521

Abstract: Sentigi (*Pemphis acidula*) is one of the mangrove species that is classified as pure stand, so it has the potential to be used as an indicator species in the mangrove area in Gili Sulat. The research location was in the regional marine conservation area (KKLD) Gili Sulat Lombok Timur. The purpose of this study was to determine the characteristics of sentigi as environmental bioindicators in the regional marine conservation area (KKLD) Gili Sulat, East Lombok. The research method is done by delineation method using high-resolution satellite imagery and *ground check*. Determination of the sampling point at the research location was determined using satellite imagery. The data analysis technique uses visualization analysis of satellite imagery catches and analysis of mangrove vegetation which is described descriptively. The results of this study indicate that a) species Sentigi can be identified using high resolution satellite imagery based on the color resolution quality of satellite imagery, namely high, medium, and low cover. (b) Sentigi species can be used as indicator plants in the Gili Sulat mangrove community based on the characteristics of environmental factors such as habitat type, habitat altitude, pH and salinity. Conclusions from this study include: (a) The distribution of the sentigi population (*Pemphis acidula*) on Gili Sulat is unique, namely in the middle of a mangrove forest. (b) population Sentigi population on Gili Sulat are grouped separately from other mangroves communities as *pure stands*. (c) Satellite imagery can be used to identify the presence of populations sentigi on Gili Sulat. (d) The presence of sentigi can be a bioindicator of sandy environments, ecoton areas, and climax succession in Gili Sulat.

Keywords: Delineation; Gili Sulat; Indicator Species; Sentigi

Introduction

The mangrove ecosystem has a distinctive vegetation structure, compiling several characteristics sequentially such as trees, saplings, poles, and seedlings, thus forming a series of certain zones Dahuri (2003). There are several type of mangrove zonations that affect the mangrove vegetation such as the *Avicennia, Rhizophora, Bruguiera*, and *Nypah* zones (Idrus, 2014). The zoning has prominent characteristics around the mangrove vegetation structure, including muddy, loamy or sandy soil types, periodically inundated by seawater, receiving sufficient fresh water supply from land such as rivers, springs and groundwater, and having strong roots (Sinfuego & Buot, 2014) Mangrove vegetation plays an important role in the preservation of coastal ecosystems physically, ecologically and economically (Rangkuti, 2017). supporting the life of organisms in the vicinity, as a habitat for birds, mollusks. and arthropods (Idrus, 2014).

How to Cite:
Al Idrus, A., Mertha, I.G., Marhus, M., & Husain, P. (2023). The Characteristics of Sentigi (Pemphis acidula) As Environmental Bioindicators of Mangrove Conservation in the Regional Marine Conservation Area Gili Sulat, East Lombok, Indonesia. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 542–549. https://doi.org/10.29303/jppipa.v9i1.2521

The potential of species sentigi (*Pemphis acidula*) as indicator plants that live around mangrove forests is very important to study its ecological footprint in interacting with mangrove plants in Gili Sulat. The characteristics of sentigi as minor mangroves need to be studied more deeply, because they live in groups on sandy substrates and are not submerged in excessive sea water. In addition, sentigi do not want to associate or live mixed with other types of mangroves. such as, several major component mangrove species on Gili Sulat, namely *Bruguiera gymnorrhiza, Rhizophora mucronata, Rhizophora stylosa, Rhizophora apiculata, Ceriops tagal, Sonneratia alba*, and *Avicennia marina* which show distinctive morphological and vegetation appearances (Idrus, 2014). If a study is conducted using satellite imagery in the Gili Sulat mangrove forest, it will show the differences in the sentigi and non-sentigi groups (mangroves in general).

Mangrove forests in Gili Sulat have very diverse mangrove species. The number of mangrove species on Gili Sulat is among the highest in Indonesia. Several major component mangrove species in Gili Sulat show distinctive and unique morphological and vegetation appearances in mangrove species including *Bruguiera gymnorrhiza, Rhizophora mucronata, Rhizophora stylosa, Rhizophora apiculata, Ceriops tagal, Sonneratia alba*, and *Avicennia marina* (Idrus, 2014). Mangrove forests are under heavy human pressure. Resulted of this loss, fishery sources, livelihood, and biodiversity are reported to be continuously declining. Another damages of mangrove vegetation were impacted by aquaculture activities, high demand for land for housing and industries, agriculture conversion, commercial logging, charcoal and fuelwood industries, and land reclamation for urban development (Abd Rahman & Asmawi, 2016)

The development of mangrove research has developed well in methods so that the analysis of vegetation becomes easier and faster, as well as in describing it. An indicator species that plays an important role in supporting the Gili Sulat mangrove ecosystem is sentigi (*Pemphis acidula*). *Pemphis acidula is* classified as an environmental bioindicator because the presence of sentigi is always found on sandy substrates in mangrove forest areas (Ulumuddin et. Al 2017, Utami & Soeprobowati. 2016). In addition, the sentigi population always forms *pure stands* so that they are easy to distinguish from other types of mangroves (Marbawa et al. 2015, Al Idrus, 2015, Ginantra et al. 2018). In addition, *Pemphis acidula* is also one of the highly reactive bioindicators of antibacterial activity, namely *V. harveyi* (Arivuselvan, 2011). In other findings, in the leafs of *Pemphis acidula* there are four typea of galloyl flavonol glycosides were found in the leaf extract of *Pemphis acidula*, that could be applied in medical sector (Masuda et al., 2021). However, a more extensive study of sentigi (*Pemphis acidula*) as an indicator to determine the structure of vegetation related to its composition and distribution pattern, has never been carried out. Therefore, the sustainability of Gili Sulat's vegetation and mangrove ecosystem needs to be maintained and preserved. Because, if the biotic and abiotic components that support the mangrove ecosystem are damaged/lost, the mangrove vegetation in Gili Sulat will also be disturbed as an integral part of the mangrove ecosystem (Husain et al., 2020).

The marine conservation area of Gili Sulat, East Lombok has a unique species, namely Sentigi (*Pemphis acidula*), and forms its pattern as an indicator species, in addition, sentigi this is in great demand by the public to be used as ornamental bonsai plants (Idrus, 2014, Utina et al., 201). *Phempis acidula* as a bonsai ornamental plant has a high enough economic value so that it has the potential to be exploited by the community (Manek, & Puay, 2020). So, the population of sentigi could decrease and loss. In several places, this species is considered as the least concern category instead of threatened (Ellison et al., 2010). The form of threats of *Pemphis acidula* such as exploitation by residents from outside the area to be traded as ornamental plants, and used for herbal medicines, traditional ceremonies, and building materials by residents (Baderan et al., 2022)

Therefore, it is necessary to conduct research using satellite imagery approaches and *ground checks* in the field to determine the structure of the distribution and distribution of species of sentigi and mangroves in Gili Sulat accurately and in detail. This research can provide scientific information about vegetation sentigi (*Pemphis acidula*). In addition, the results of this research can be a scientific basis for mangrove conservation on a local scale, such as in research areas and other relevant locations.

Method

Study Site

Research was conducted in Regional Marine Protected Areas (KKLD) Gili Sulat East of Lombok, Indonesia. It was conducted since September until November 2020. Furthermore, research data was obtained through the observation method at six stations that had been determined by satellite imagery (SPOT 7). Meanwhile, three stations, namely stations II (08°19'02.08" S, 116 °42'29.01" E), IV (08°18'55.73" S, 116 °42'33.23" E), and VI (08°19'01.07" S, 116 °42'33.58" E) are potential areas for Sentigi indicator species. Meanwhile, Stations I (8°19.5540" S, 116 °42.7880" E), III (8°19.1580" S, 116 °42.7640" E), and V 8°18.9000" S, 116 °42.5860" E) are mangrove areas bordering the Sentigi habitat. The research location of Gili Sulat, Lombok Island West Nusa Tenggara Barat is shown in Figure 1.

Figure 1. Research Location Map

Data Collection

Data collection was carried out in stages: data collection using the delineation method, which is a technique for collecting vegetation data using high-resolution satellite image surveys in the Gili Sulat mangrove area (Regulation of Director General of Forestry Planning and Environmental Management Regulation, 2017 Furthermore, the steps are as follows:

1. Prepare tools and materials

   Materials and equipment for surveying Gili Sulat mangrove forest area that need to be prepared include High-resolution satellite imagery with a spatial resolution of 0.6-4 m (SPOT-7), large-scale RBI Map (1:50,000), GPS, Camera, Compass, External hard drive, tally sheet and stationery.

2. Create a land cover map.

   Interpretation of high-resolution satellite imagery using the classification of 23 land cover classes issued by SNI. Then, make polygons for each land cover class (primary mangroves: high, medium, low density; secondary mangroves: high, medium, low density), with the smallest polygon size of 0.25 Ha. Delineation was also carried out on specific land cover suspected as sentigi covering form (*Pemphis acidula*) in each land cover class polygon. So that the sampling point on each polygon can be determined. Finally, print out a graded land cover map at a scale of 1:50,000 or 1:25,000.

3. Field observation (*ground check*)

   Observations were made to determine the existing conditions in the field as follows:

   a. Land cover by mangroves.
   In each land cover class polygon, mangrove species were verified including low, medium and high cover classes. Similarly, the specific land is suspected of being sentigi (*Pemphis acidula*). Observations growing as a mixed community (associated), demand (or pure population, which will be determined based on vegetation analysis. Each plant group in the area delineation is also verified against the boundaries of the covered area).

   b. Physical field. Physical field conditions recorded such as place of growth, substrate pH and salinity, topography, and landforms.

4. Recording spatial

   Data Field spatial data recorded are sample point numbers, sample point coordinates, land cover boundary coordinates, measurement results of tie points, photos of sample points, and information other than is not obtained in the image (Singh et al., 2014).

The next stage is data on collecting sentigi (*Pemphis acidula*) and mangroves in the Gili Sulat mangrove area. using a line *transect*. Transect lines are placed systematically by pulling the transect straight to the coast and intersecting the mangrove formation. This data collection aims to determine the diversity of species and the important value index (INP) of mangroves (Pradnyawati, 2018; Ahyadi et al, 2018). In addition, plotted transects (plots) are also used to determine the pattern of zonation of the sentigi. Observation plots were placed alternately on each transect. Transect made as many as 10 plots were laid continuously with the square of the size and growth rate of the different vegetation (Idrus,2014):

1) Seedling, ranging from a high germination to the tiller as high as 1.5 meters to less than 1.5 m, with stem diameter (Ø <5 cm) and a plot size of 2 x 2 m
2) Sapling, is the rate of growth of vegetation that is still young with a height of 1.5 meters with a diameter of rod (5 <Ø <10cm), with size plot 5 x 5 m
3) Tree, it has more than 1.5 m high with a diameter of the stem (Ø)> 10 cm (dbh), with a plot size of 20 x 20 m.

The Parameter abundance of each species was scored by the cover scale and tree abundance regarding the Braun-Blanquet (BB) scale. The technique of processing data collected in the field is then processed first using vegetation analysis to obtain an Important Value Index (INP). This significance value is obtained from the sum of relative density, relative frequency, and relative dominance using the calculation formula for vegetation analysis (Odum, 1972).

Environmental parameter

Collecting data on abiotic environmental factors such as substrate (soil), pH (degree of acidity), temperature, and humidity using tools that have been provided to enrich data and information related to the structure of the distribution and boundaries of the Sentigi and Gili Sulat mangroves in general.

Data Analysis

Data obtained from the field are then analyzed by reclassifying (reinterpreting), namely improving delineation based on the results of *ground checks*, improving interpretation class labels, and calculating the area of the interpretation class. As well as analyzing potential data that supports the sentiment (*Pemphis acidula*) as a species-specific land cover indicator in high-resolution satellite imagery and a bioindicator of the edaphic condition of the mangrove substrate.

Result and Discussion

The Vegetation Cover of Mangrove in Gili Sulat Vegetation cover mapped based on the interpretation of the SPOT 7 2014 satellite image is shown in Figure 3. Based on the interpretation of the image map, the classification of vegetation in Gili Sulat is generally in the form of mangroves which are grouped as dense mangrove forests, medium mangrove forests and low mangrove forest. Another visible vegetated area is dry land forest. Areas that are mostly open but still have vegetation (specific vegetation cover) including low mangrove forest are spread over 10 (ten) locations (Figure 2) Out ofthe ten locations, there were 3 (three) locations that showed distinctive color characteristics which were clarified as a population sentigi (*Pemphis acidula*). Vegetation cover at the three locations is very different from the mangrove cover at all densities in Gili Sulat. The covering of mangrove Gili Sulat was decribe in Figure 2 (b) which is classified into four categories namely mangrove forest, medium mangrove forest, low mangrove forest and dry land. The largest mangrove covering is the mangrove forest. The Sentigi species had been found in the special area which grows in the sand habitat near the seashore in the mangrove forest in the KKLD Gili Sulat area. *P. acidula* has relation to *Punica granatum*, both are members of the family Lythraceae (Jian & Ren, 2019).

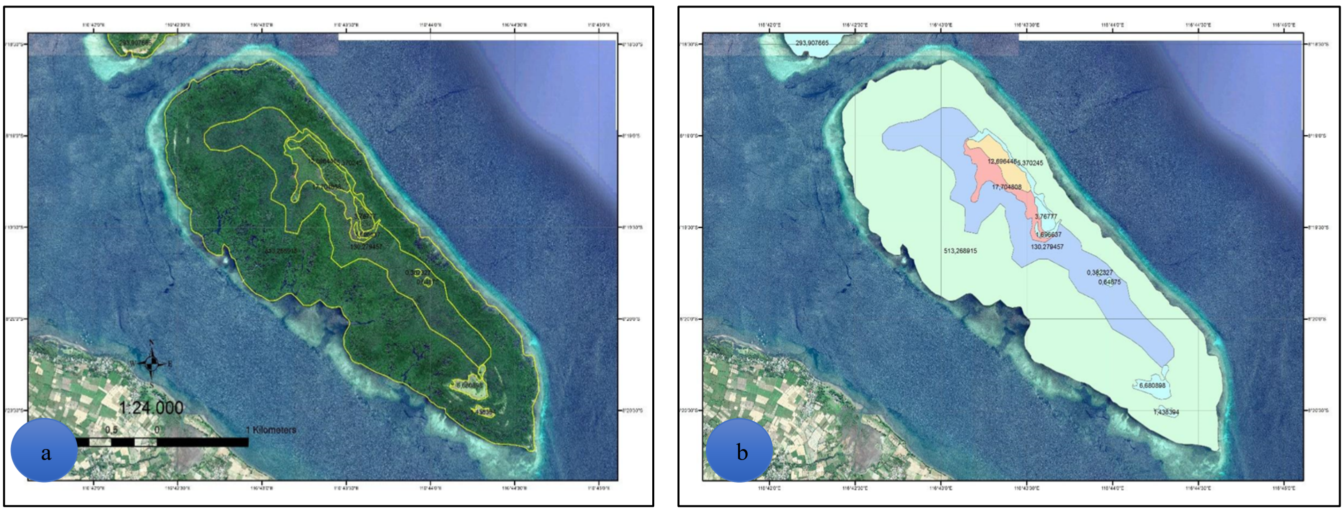

Figure 2. Land cover in KKLD Gili Sulat, East Lombok

Based on digital classification with supervised classification method) on two land cover classes can be determined for the mangroves and dry forests. Through the results of the guided classification, the total land cover area in Gili Sulat is 685.81 ha. Types and classifications of land cover in Gili Sulat, along with their area, are shown in Table 1.

Table 1: Land cover area in Gili Sulat, East Lombok

Land cover classification	Area area (ha)	Percentage of area areas
Mangrove forest	513.27	74.27
Medium mangrove forest	130.28	19.00
Low mangrove forest	29.56	4.31
Dry land forest	12.70	1.85
Total	685.81	100

Land cover in Table 1 shows that mangrove forest (mangroves) has the widest land cover reaching 673.11 ha or 97.58 percent of the vegetated area in 2014. The mangrove forest land cover is composed of dense and medium cover. Meanwhile, terrestrial forest only occupies 1.85 percent of the vegetated land area. While the specific land area which is the habitat of sentigi is in three locations with an area of 0.98 ha, 0.68 ha and 0.45 ha, respectively. Meanwhile, on the south coast of Lombok Iskand, the vegetation structure of mangrove ecosystem is majority composed of *Rhizophora stylosa* and *Sonneratia alba* (Idrus et al., 2021).

Data from remote sensing or satellite provides quantitative information on understanding the spatial distribution of mangrove forests (Giri, 2008). Remote sensing technology has been applied in various ways to characterize mangrove ecosystems. Some of the documented applications include mapping the areal extent, detecting individual species, and providing estimates of structure and parameters such as leaf area, canopy height, and biomass (Heumann, 2011).

Ground check verification of the existing mangrove forest cover Pemphis acidula following the instructions on satellite image

Ground check is carried out to verify the data between the image of the actual condition of objects in the image with the reality on the ground. The determination of the coordinates of the plant sample points is classified carried out with the help of a GPS device. Observations were made mainly on the presence of plants whose species were suspected to be true and other information that was not obtained in the image. During this field check, the transect coordinates of land cover boundaries were also determined to check polygon boundaries. The results of checking the polygon boundaries are used to improve the delineation of land cover that has been interpreted on the image map.

Field clarification by conducting a ground check on environmental parameters on specific and non-specific vegetation cover in each polygon. Satellite imagery shows differences in substrate conditions (Figure 3). All spots (polygons) in specific vegetation cover are areas with sandy edaphic conditions. Meanwhile, non-specific polygons (around or between specific areas) are muddy substrates. The sandy substrate is higher in elevation than the muddy substrate (Marbawa et al., 2015). Thus, muddy substrates are often submerged in seawater compared to sandy substrates, resulting in two very different habitats (Darmadi et al., 2012). The edge of the sandy habitat (specific spot) is an ecotone (transitional) area that separates the vegetation in the sandy habitat from the vegetation in the muddy habitat (Figure 3). The existence of differences in the distribution of substrate texture at each station can be influenced by differences in the density of mangrove vegetation. The higher the density of mangrove vegetation, the higher the litter produced and the stronger the ability of mangrove roots to bind to the substrate (Aini et al., 2016).

The results of the ground check of vegetation at five locations shown on the satellite image map show that there are two community groups (Figure 3). Observation of vegetation in polygon II consists of one pure stand plant species bordering ecotone species. Similarly, polygons IV and VI have the same type of population arranged as the population in polygon II. Unlike the three polygon locations, the vegetation in areas I, III, and V is composed of several plant species in mixed stands. Based on the data obtained, it is shown that satellite imagery can be used to distinguish groups of mangrove vegetation in Gili Sulat.

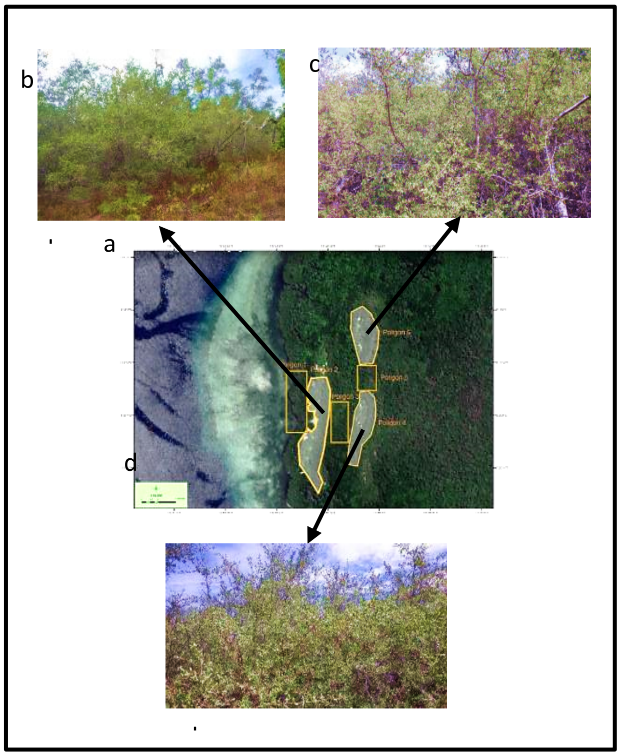

Figure 3. Sentigi population in Gili Sulat (a) division of polygons in all mangrove cover areas in satellite imagery, (b) population sentigi in polygon II (c) population sentigi in polygon VI, (d) cover sentigi in polygon IV

Pemphis acidula is a distinctive feature, as an indicator species providing a comprehensive picture of its distribution. *Pemphis acidula* vegetation develops and spreads throughout the midle area, towards the terrestrial and away from the aquatic area (Idrus et al., 2021). *Pemphis acidula* is a type of mangrove that has the highest importance at the tree, sapling and seedling levels for vegetation in polygons II, IV, and VI (Table 2). At the tree level, in polygon IV there are two groups of vegetation, namely sentigi (*Pemphis acidula*) and other mangrove association plants including *Diospyros maritimea*, *Tamarindus indica*, *Mimusops elengi* and mangroves with minor components *Excoecaria agallocha*. The number of Sentigi in this area reached 70.55 percent based on the comparison of INP values. The significance value of *Pemphis acidula* in polygon VI was higher than that in polygon IV which reached 73.84 percent when compared to the surrounding species which stood *Excoecaria agallocha*. Although there were more *Excoecaria agallocha,* the dominance of *Pemphis acidula* in this sandy habitat was the highest compared to other polygons. At the sapling and seedling level, no other plants were found around the population sentigi so this species was the only one that controlled the sandy land in the three locations. Based on the results of this data verification, the distinctive colors displayed on satellite images can be used to identify the population sentigi on

Gili Sulat. Meanwhile, other species around the population sentigi cannot be well recognized in satellite imagery, possibly due to their sporadic distribution, not clustered in *pure stands* and less specific color reflections. The results of this study differ from the classification issued by the National Standardization Agency (2010) that the mangrove forest area is a stretch of land cover. *Pemphis acidula* Forst is a tropical sea-shore plant species, distributed from East Africa to the Pacific Ocean. Its morphology can vary from a scrambler to a tall shrub and grows on raised coral and rocky or sandy beaches above the intertidal zone (Ellison et al. 2010).

Table 2. Types of tree-level, saplings and seedlings (*seedling*) at 3 (three) locations that were leniated in each of them polygon II (08º19'02.08" S, 116 º42'29.01" E), polygon IV (08º18'55.73" S, 116 º42'33.23" E), and polygon VI (08º19'01.07" S, 116 º42'33.58" E) in Gili Sulat, East Lombok.

Polygon II			Polygon IV			VI polygon		
tree type	INP	Σ	tree type	INP	Σ	tree type	IVI	Σ
Pemphis acidula	225.64	31	*Pemphis acidula*	211.65	50	*Pemphis acidula*	220.45	8
Type vicinity	74.36	5	aroundType	88.36	4	Type vicinity	79.55	1
Sapling			type Sapling			type		
Pemphis acidula	300	56	*Pemphis acidula*	300	36	*Pemphis acidula*	300	17
Surrounding type	0	0	Surrounding type	0	0	Surrounding type	0	0
Seedling			type Seedling			type		
Pemphis acidula	200	1	*Pemphis acidula*	200	1	*Pemphis acidula*	200	1
Types of	0	0	Types of surroundings	0	0	Types of surroundings	0	0

Source: Primary data processed (2021). Description: = number of individuals.

Based on the results of ground checks on non-specific polygons, mangrove data was obtained as presented in Table 3. The types of mangroves found in polygons I, III, and V were different from those found in polygons II, IV and VI. Mangrove stands in the three polygons are a combination of several types of plants (mixed vegetation). At the tree level, the types of mangroves that make up this community include major component true mangroves and minor component true mangroves. The major component includes 6 (six) mangrove species while the minor component is only 1 (one) species. At the sapling and seedling level, no minor components were found. A similar study found there are two mangrove which form a group they are *Rizophoa mucronata* dan *Rizophora stylosa*. Where, the where the tree level diversity index was in the medium category, and the sapling and seedling levels were in the low category in Tanjung Pajang Nature Researve Area (Bedaran et al., 2018) In mangrove vegetation in the tracking area on Kemujan Island Karimunjawa National Park, Indonesia, had been reported that there are 12 species where *Ceriops tagal* had the highest important value index at the seedling level (126.26%) and sapling level (121.07%). While, tree level *Lumnitzera racemosa* dominated (117.82%) (Winata et al., 2017).

Table 3. Types of mangrove plants at the tree, sapling and *seedling level* at 3 (three) polygon locations including polygon I (8º19.5540" S, 116 º42.7880" E), polygon III (8º19.1580" S, 116 º42.7640" E), polygon V (8º18.9000" S, 116 º42.5860" E) in the Gili Sulat mangrove, East Lombok.

I Polygon			Polygon III			Polygon V		
Type Trees	INP	Σ	Trees Type	INP	Σ	typetree	IVI	Σ
Rhizophora mucronata	43.24	4	*Rhizophora mucronata*	59.27	4	*Rhizophora mucronata*	134	16
Rhizophora stylosa	139.92	18	*Rhizophora apiculata*	101.88	10	*Ceriops tagal*	128	20
Rhizophora apiculata	36.53	3	*Rhizophora stylosa*	78.64	6	*Lumnitzera racemosa*	38.1	1
Sonneratia alba	37.52	2	*Sonneratia alba*	32.12	1			
Osbornia octodonta	21.01	1	*Ceriops tagal*	28.08	1			
Lumnitzera racemosa	21.78	1						
type	Sapling		type Stake			Stake kind		
Rhizophora mucronata	82.60	4	*Rhizophora apiculata*	154.05	*10*	*Ceriops tagal*	270.08	37
stylosa Rhizophora	156.28	10	*Rhizophora stylosa*	76.62	*4*	*Rhizophora mucronata*	29.92	1
alba Sonneratia	61.12	2	*Sonneratia alba*	69, 33	*2*			
			Seedling Type of					
Type of			Seedling			Type of Seedling		
Rhizophora mucronata	66.67	1	*Rhizophora apiculata*	100	1	*Ceriops tagal*	200	1
Rhizophora stylosa	133.33	2	*Rhizophora stylosa*	100	1			

Source: Primary data processed (2021). Description: = number of individuals.

The types of mangroves that make up the stands in the polygons as shown in Table 4 are dominated by members of the Rhizophoraceae tribe. *Rhizophora stylose* is the most dominant major component in polygon I. Polygon II is dominated by *Rhizophora apiculata*. In polygon V the most dominant species is the true mangrove *Ceriops tagal*. Although in each polygon there is a dominant species, these types form a community that is a combination of several other types. The results of the *ground check* and vegetation analysis strengthen the satellite imagery evidence that the types of mangroves in this combination are difficult to distinguish, The resulit of study follows the classification issued by the National Standardization Agency (2010). However, the image on the satellite image can be used to distinguish this mangrove group from the population sentigi (*Pemphis acidula*). A similar study also found that sentigi is one of the mangrove species that could be easily identified, because of a pure stand forming, for example the mangrove species in Banggai, that the mangrove had been classified into 53 species, consisting of 25 true mangrove species and 28 associated mangrove species. Among the true mangrove species growing in Banggai are *Avicennia, Sonneratia, Rhizophora, Bruguiera, Xylocarpus*, and *Lumnitzera*. Rhizophoraceae has the highest number of species, namely *Bruguiera gymnorrhiza, Rhizophora mucronata, R. apiculata, Rhizophora stylosa,* and *Ceriops tagal*. While *Pemphis acidula* has been found separated with the sandy habitat from another species (Utina et al., 2019). Besides, *Pemphis acidula* could be categorized as a rare species among the mangrove vegetation because of its functional and economic usage so that it is traditionally harvested and valued as a bonsai species (Ellison et al., 2010, Utina et al., 2019).

Identification of environmental parameters sentigi (Pemphis acidula)

The habitat where it grows is sentigi different from the surrounding mangrove environment. The area Sentigi on Gili Sulat is surrounded by muddy soil. There is only one location, namely polygon II, some of which are directly adjacent to the beach as is common in mangrove areas elsewhere. In contrast to these locations, Polygon IV and Polygon VI support the stand of the population sentigi in the middle of the mangrove forest. This condition is very typical for sentigi in Gili Sulat because it has never been reported in other places. Related to environmental parameters, The preferable salinity level of *Pemphis acidula* was reported as between 26-30 g/L. and most suitable areas for the distribution of the plant. *P acidula* were not present in the sites where salinity was less than 20g/L, which indicated that the species prefer high salinity levels. *P. acidula,* which has high potential to exterminate dengue larvae and has strong antibacterial activity has been reduced drastically due to clearings of mangroves (Gunathilaka, 2017). *Pemphis acidula* species tend to form special stands in the seashore of mangrove vegetation, for instance, on Menjangan Island, sentigi tend to be stunted, low, and sparse with stems that often bend, then their habitat is sandy and is in relatively high altitudes (Marbawa et al., 2015). Besides that, it can be differentiated from antoher pure stands such as *Rhizophora, Avicennia*, *Sonneratia*, and *Bruguiera* of mangrove species. *Pemphis acidula* has been reported in five island atoll nations and this species is an indicator species of the coral-rich ecosystem (Sivakumar et al., 2018).

Table 5. Environmental conditions *Pemphis acidula* in the regional marine conservation aea Gili Sulat

Environmental parameters	Polygon 1	Polygon 2	Polygon 3
Substrate type	Sandy, white sand mixture.	Sandy, white sand mixture.	Sandy, white sand mixture.
Substrate pH	6.3-6.4	6.4-6.6	6.3-6.5
Temperature	35-36^{0}C	34.5-35^{0}C	34.7-35.5^{0}C
Substrate depth	20-30 cm	15.28-33	25-32 cm
Elevation (asl)	30.55-30.75 m	34.38-34.44 m	33.69-33.71 m
Humidity	60-62%	52-54%	51.5-53%Site
conditions	Part of terrestrial habitats and ecotones	Part of terrestrial habitats and ecotones	Part of terrestrial habitats and ecotones
Other	Coral	fragments found Coral fragments and mollusk shells	found Coral fragments

Source: Processed primary data (2021)

Field observations indicate the presence of sentigi can be an indication of certain environmental conditions in mangrove forest areas. Sentigi has habitat preferences as listed in Table 5. The general condition that can be described due to the presence of sentigi (*Pemphis acidula*) in a mangrove area based on these data is that the environment where this species grows is a sandy habitat. Sentigi was founding the higher in elevation than sea level. Similarly, the pH and salinity are typical for the habitat sentigi compared to the surrounding muddy areas that are continuously exposed to seawater rinses. The condition that occurs in Gili Sulat is that with the presence of white sand and coral fragments in an open area it will be easy to read visually on satellite imagery and this picture is closely related to the presence of the population sentigi.

Pemphis acidula lives in an inlet at the seafront bordering the mangrove forests on sandy shores (strewn with washed out coral rubble) and on calcareous rocky habitats above the high tide level at the landward margin of mangroves (Goutham-Bharathi, et al., 2015).

Identification of vegetation cover and classification population of sentigi (Pemphis acidula)

Satellite imagery is closely related to the identification of land cover, both vegetated land and open areas. The Standardization National Agency (2010) has accommodated the diversity of land cover classes whose details vary between *shareholders* which are then compiled in standards. However, the standards made are still general, so for classes in cover more detailed land, there is still an opportunity for producers to carry out development according to their main tasks. The use of satellite imagery to determine the general description of vegetation has been widely carried out, even not only general descriptions but identification of more specific objects to the determination of plant species can be done easily. Sengon forest, white teak forest, rubber forest, jelutung forest, bamboo forest and many other forest types can be detected with the help of satellite imagery (Sari et al., 2016).

Forests that are formed from a single stand of these tree species are easily marked on the image because they show a distinctive picture and distinctive color. If a forest area comprises with a *pure stand* of mangrove species, the constituent types will be easily identified. In contrast to monoculture forests, determining land cover composed of various plant species is not easy to do using satellite imagery. The colors displayed differed between species and the characteristics of the stands that varied between species made identification difficult. Therefore, for areas where land cover is composed of various species, such as in natural forests, only forest type, and density class can be determined. The characteristics of *Pemphis acidula* comprise a small spreading tree, a high range between 7 up to 9.5 m; Bark light grey to brown; deeply fissured with age; roots adventitious, spreading, exposed with no specialized adaptations. Leaves thick, decussate, narrowly elliptic to lanceolate; densely covered with silky hairs on both surfaces, 1.4–3.5 (2.61) × 0.4–1.5 (0.99) cm with a very short petiole (up to 1mm) (Goutham-Bharathi, et al., 2015).

Mangrove forests (mangroves) are forest areas located on wetlands composed of various stands of typical species adapted to muddy and sandy water areas including forest areas which according to the National Standardization Agency (2010) are only one land cover as the mangrove forest. The detailed description of the mangrove forest only reaches the high, medium, and low-density classes. Observation of satellite imagery shows that many specific lands cover types in this forest area have not been described by the National Standardization Agency (2010). Identification of landscape using satellite remote sensing provides an effective means for diagnosing ET patterns over the heterogeneous landscape. It has various types for different assessment parameters such as land topography, temperature, and land surface (Yang et al., 2017).

The results of the study on the mangrove forest area on Gili Sulat proved that the specific land containing the population sentigi (*Pemphis acidula*) depicted in the satellite image could be identified correctly after conducting *ground check* in the field. The population of sentigi is easily recognized visually on satellite imagery of the mangrove area because this plant species forms pure *stands in* large numbers and is dense in the field. Based on these conditions, the color display produced by the sentigi is very distinctive and contrasts differently from another mangrove cover, which is light green and grayish white. The findings of this study have not been listed in the standards of the National Standardization Agency (2020). The assessment of landscape using satellite data could examine stand parameters and detect degradation and forest dynamics, such as above-ground biomass (AGB), because it works for focusing on spectrum-based and radar backscatter approaches for assessing forest biomass on the ecological landscape (Singh et al., 2014).

Pemphis acidula as a bioindicator species in mangrove vegetation

As a minor mangrove, sentigi (*Pemphis acidula*) have special environmental requirements to continue their growth and reproduction growth. Sentigi habitat in Gili Sulat shows some similarities with populations in mangrove areas elsewhere, for example, sentigi found in Central Sulawesi (Utina *et al*., 2019), Daiama Village, NTT (Ngoma *et al*., 2020), Maubesi, NTT (Manek & Puay, 2020).

Sandy areas are characteristic of habitat sentigi. The presence of sentigi (*Pemphis acidula*) can be an environmental indicator of a mangrove with a sand substrate among the mangrove vegetation (Goutham-Bharathi, et al., 2015). Sandy areas are generally found in areas directly adjacent to the sea or on the coastline. Thus, the presence of sentigi is generally found on the edge of the mangrove forest and is an indicator of a sandy beach area. The degree of acidity and salinity of the sentigi area also showed significant differences with the mangrove environment found in muddy land. Based on environmental parameters, *Pemphis acidula* becomes a good bio-indicators as a guide in Gili Sulat environmental conditions. The distribution of sentigi on Gili Sulat is unique because of the presence of a population that does not grow on the beach. The presence of sandbars in the middle of the mangrove forest creates suitable conditions for colonization, growth, and development of the sentigi (Sivakumar et al., 2018).

Conclusion

This study concludes that the population distribution of stands sentigi (*Pemphis acidula*) in Gili Sulat has a peculiarity that is in the middle of a mangrove forest. The population of Sentigi stands on Gili Sulat are grouped separately as *pure stands*. Satellite imagery can be used to identify the presence of populations sentigi on Gili Sulat. The presence of sentigi can be an environmental bioindicator such as sandy habitat, ecoton areas, and climax succession in Gili Sulat.

Acknowledgements

PNBP research team expressed gratitude to the Rector of the University of Mataram and the Institute for Research and the Community Service University of Mataram which has provided material assistance so that the research activities carried out smoothly.

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