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Original article

Habitat of *Maranthes corymbosa* Blume in Sempu Island Nature Reserve and the ex situ conservation efforts

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Abstract

Sempu Island Nature Reserve is an island conservation area that located in East Java. One of tree species that grows in the Sempu Island Nature Reserve is *Maranthes corymbosa*. This species is known as "triwulan" by local people. Triwulan is known as one of the plant species that has potential as building materials. Therefore, even though the conservation status of this species is still classified as safe according to the WCMC (1998) or World Conservation Monitoring Centre (i.e. LC or Least Concern), it can still experience threats because of the benefits of the wood which are known to the public. The condition of *M. corymbosa* itself in Sempu Island NR is still relatively well preserved because it may be due to the status of Sempu Island NR as a relatively protected conservation area. This study aims to determine the condition of the natural habitat of *M. corymbosa* in the Sempu Island NR and to provide additional information about several conservation efforts that have been carried out. *M. corymbosa* was commonly found in habitats at lowland areas, with low light intensity or shady places and in cool or humid areas in Sempu Island NR. Ex situ conservation efforts for this species have been carried out by several botanical gardens in Indonesia (Purwodadi BG, Bogor BG and Cibodas BG), one of which is by making it a collection in the garden area.

Keywords: habitat, triwulan, *Maranthes corymbosa*, Sempu Island Nature Reserve, ex situ conservation effort

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Introduction

The condition and status of the Sempu Island NR which was designated as a conservation area has more or less a positive contribution to save the existence of the plants in it. As a conservation area with a coastal forest ecosystem type, lowland rain forest in Java, Sempu Island NR still has relatively well-maintained natural conditions. Irawanto et al (2017) stated that the results of a literature search on vegetation in Sempu Island NR recorded that 282 plant species were recorded to be found growing in this area. One of them is *Maranthes corymbosa*, which is known as

The presence of *M. corymbosa* has ecological function in Sempu Island, because this species makes the largest contribution to carbon stocks in Sempu Island (Danarto et al 2018). The potential use of this species is mainly in the use of its wood for house buildings and posts (Slik, 2009). It is also known by the trade name of *kolaka* wood, which is widely used for building materials, flooring, boards, bearings and also shipping wood. In Malaysia, this species is known as *merbatu* wood trade or *bangkawang* (Lim, et al 2001; Soepadmo & Wong, 1995). This type of wood is easy to preserve because it is easy to be added preservatives (Anonym, 2016; Anonym, 2016b). Utomo (2012) suggested that the wood character of *M. corrymbosa* can be used as raw material for making traditional fishing boats in the Kendari region, Southeast Sulawesi. Smith (1991) noted that the wood from this tree trunk was used to make boats/canoes by Aboriginal people in northern Australia. In addition to direct use, the existence of this species can actually provide benefits to the environment and ecosystem. The fruit is edible. Ecologically this species plays an important role, because the fruit is used as food for various types of birds and mammals. Hornbill eats fruit and is also a dispersal agent of this type. The nectar contained in flowers is also used as food for various types of bees. Anonym (2013), explained that the *M. corymbosa* species in Darwin-Australia known as the *white cloud tree*, is a plant species capable of providing ecosystem services for the lives of several reptiles, butterflies, birds and mammals. Its stature in the form of a large tree with a height of 10-25 meters is used by various wildlife for their habitat. Laatung's research (2015) explains that *M. corymbosa* is used by *yaki* (*Macaca nigra*) as a place to sleep in the Tangkoko Dua Saudara Nature Reserve, North Sulawesi. Its tall stature and dense canopy conditions favor this benefit for the *yaki*.

Sempu Island NR is an island conservation area located in Malang Regency, East Java. The history of determining this conservation area is quite old, because as a conservation area its management has been carried out since the Dutch colonial period. The legal basis for his appointment was Besluit van den Gouverneur Generaal van Nederlandsch Indie No: 69 and No.46 dated March 15, 1928 regarding Aanwijzing van het natourmonument Poelau Sempoe. The area of this

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conservation area is 877 ha, with its geographical boundary being surrounded by the Indonesian Ocean. Geographically, Sempu Island NR is located between 112°40'45" East Longitude and 8°24'54" South Latitude. Administratively, the Sempu Island NR area is located in Sendang Biru, Tambak Rejo Village, Sumbermanjing Wetan District, Malang Regency, East Java Province. Its condition which is separated from the mainland of Java Island (although only a few km), is something that is very interesting related to the diversity of plant species that exist there (Figure 1).

Sulistyowati (2008) stated that the results of vegetation sampling conducted at Sempu Island NR showed that vegetation on Sempu Island has a high level of rarity and endemicity. A total of 54.54% of the vegetation on Sempu Island is categorized into the unique category and 32.73% is classified into the very unique category. Vegetation conditions in Sempu Island NR are still relatively good. This is because the intensity of contact with human activities is very small. Only on the north and northwest sides of the island are easy to reach by fishermen's activities.

The exploration and research of the flora of Sempu Island conducted by the Purwodadi Botanical Gardens aims to document, collect and conserve existing plant species for ex-situ conservation of plants in the botanical gardens. This research activity focused on several areas in the forest block in Sempu Island NR, namely: Waruwaru, Air Tawar, Teluk Semut, Segara Anakan and Telogo Lele to describe the habitat of *M. corymbosa* in Sempu Island NR. This study also present the conservation efforts done for this species.

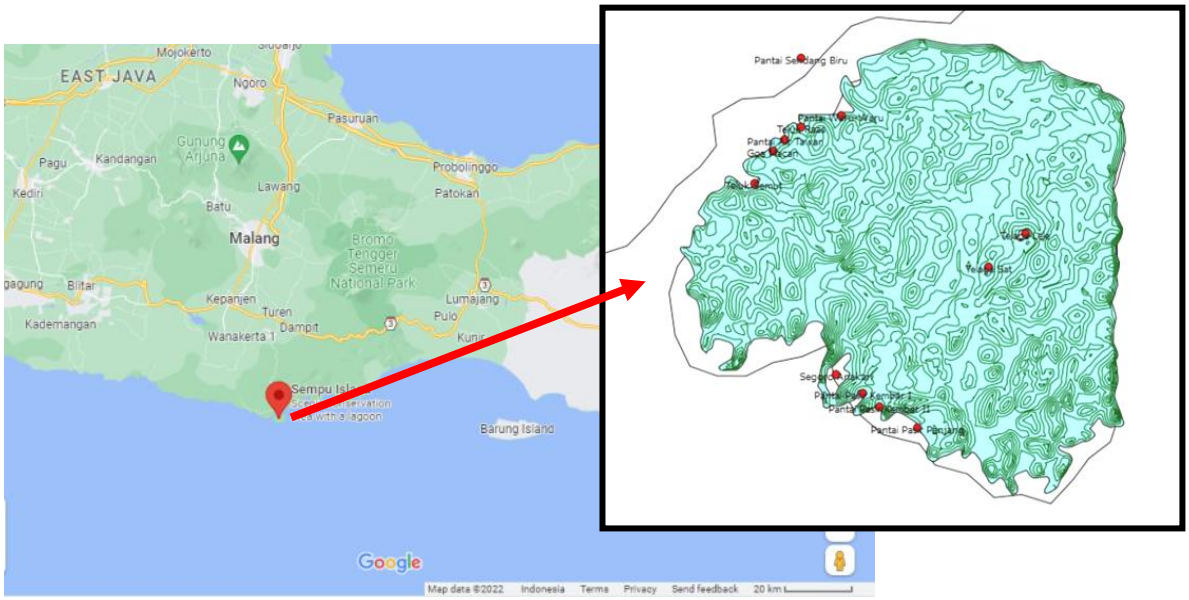


Figure 1. Map of the location of the Sempu Island Nature Reserve (Source: Google Map & Irawanto, 2017)

Method

Research activities were carried out in 8-15 April 2015 exploring the Waru-waru -Air Tawar - Teluk Semut route, in 6 – 13 May 2015 exploring the Teluk Semut-Segoro Anakan route, and on 20-27 April 2016 exploring the Waru-waru - Telogo Lele route.

The equipment used in this study included: herbarium specimen making equipment, plant material collection and processing equipment, Garmin Etrex GPS type, digital camera, field book, pH meter, lux meter and thermo-hygro meter.

Research was done by exploring forest areas to get an overview of the habitat conditions where *M. corymbosa* grows (Rugayah et al, 2005). The activities carried out were to record every point of encounter with *M. corymbosa* (geographical position), equipped with environmental data such as air temperature, humidity, light intensity, soil pH and altitude at each location.

Data analysis was carried out descriptively with comparisons through literature studies on research and research that had been carried out on this species. The description of the discussion covers aspects of morphological and taxonomic characters, distribution and habitat, status and conservation efforts and their use. To find out the description of the habitat conditions of *Maranthes corymbosa*, an environmental gradient ordinance analysis was carried out using the Principle Component Analysis (PCA) method. This was done to determine the effect of environmental factors on the place where this species grows. Analysis of this data used the PAST software version PAST 3.26 (Hammer et al. 2001).

The geographic location data of the *Marathes corymbosa* distribution which is documented in GPS were then transferred and stored to be displayed on a map using MapsSource and Google Earth software.

The collected plant material (herbarium specimens and living material) were then be registered and managed as collection plants of the Purwodadi Botanical Gardens. The herbarium material become the collection of Pasuruan Herbarium Hortus Botanicus Purwodadiensis (PHBP), while the living material were planted in the garden to add to the collection of the Purwodadi Botanical Gardens.

Results

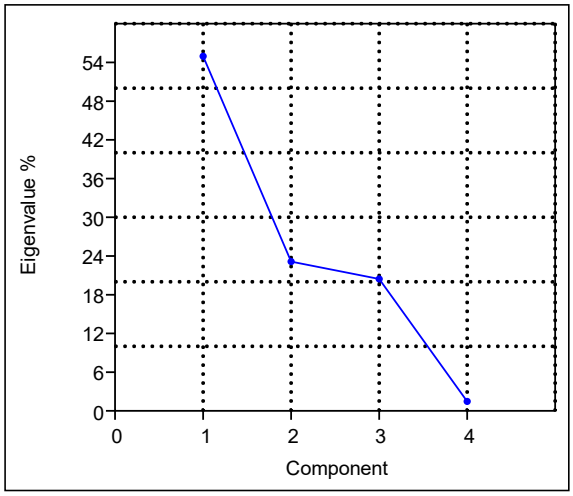
This species was generally found in the form of large trees. The young generation of this species was also commonly found. However, the number of *M. corymbosa* population was not counted in this research. There were ten locations where encounters with *M. corymbosa* were recorded and documented in this study (Table 1). Map of the location of the encounter with *M. corymbosa* is shown in Figure 2.

Based on the environmental data that was collected at ten encounter points of *M. corrymbosa* trees, the principal component analysis was then carried out. This analysis is to determine the environmental factors associated with the environment in which it grows. The observed physical environmental parameter values are shown in Table 1.

Table 1. List of locations where *Maranthes corymbosa* grows and encounters in Sempu Island NR

Location point	Altitude (m dpl)	Temperature (°C)	Air humidity (%)	Light intensity (Lux)	Location
Tw1	27	28	82	100	Wr
Tw2	28.24	27	85	188	Wr
Tw3	31	30	82	385	Wr
Tw4	26.24	31.3	61	7300	Tlsm
Tw5	26.2	32.9	85	723	Tll
Tw6	27.14	29.8	82	2830	Wr
Tw7	28.15	32.1	85	727	Sgr
Tw8	42.72	29.6	82	215	Wr
Tw9	56.44	30.2	83	819	Wr
Tw10	48.52	28.5	84	618	Tll
Average	34.17 ±10.97	29.94 ± 1.82	81.10 ±7.19	445.60±252.64	

Figure 2. Location of *Maranthes corymbosa* in Sempu Island NR



PC	Eigenvalue	% variance
1	**2.19818**	**54.955**
2	0.925481	23.137
3	0.817471	20.437
4	0.0588661	1.4717

Figure 3. Scree plot and eigenvalues from PCA analysis.

The results of the Principle Component Anal tal factor is using the PAST program show that the environmental factors where *Maranthes corymbossa* grows can be grouped into one main component which is characterized by an eigenvalue >1, namely PC1 (Figure 3). Whereas shown in Table 2 and ordination graph of PCA analysis results on environmental factors where quarterly growth in Sempu Island NR is shown in Figure 4. Figure 5 shows the morphological characters of *M. corymbosa*.

Table 2. Eigenvectors values for each environmental factor

	Axis 1	**Axis 2**	Axis 3	Axis 4
Alt (altitude)	-0.4686	**-0.6254**	0.6238	0.009119
Suhu (temperature)	0.4875	**0.5789**	0.6532	-0.02135
%udara (humidity)	**-0.913**	0.3703	0.03906	0.1665
Lux (light intensity)	**0.9525**	-0.2491	0.01003	0.175

Discussion

M. corymbosa was mainly found in the form of large trees, with abundant flower fall on the forest floor; this is in accordance with the flowering period which occurs between April-November at the time of this research (Prance, 1989). *M. corymbosa* comes from the Greek, namely *marainono* which means to have long and withered flower (petals and stamens) ornaments, and *corymbose* which means to cluster. This refers to the characteristics of this plant, which has flowers arranged in clusters with flexible floral ornaments (Soepadmo & Wong, 1995). *M. corymbosa*'s stature is a large tree with a trunk diameter of more than 1 meter, small buttresses, a tree height of about 15-20 meters. The inflorescence is terminal with flowers arranged in an umbrella (corymbos). Flowers are white with a yellowish base (Figure 5). Some characteristics that are easily recognizable for *M. corymbosa* include: having a clear main stem, with a fairly thick bark, light gray in color. It has a small buttress at the base of the trunk. It has single leaves arranged opposite, elliptical, elliptical-tapered, obovate to oblanceolate. The average leaf size ranges from 4.5-17.6 cm for leaf length and 1.6-6.5 cm for width. The leaf edge is flat with a tapered leaf tip. The upper surface of the leaves is glabrous and glossy while the lower surface is glabrescens and has fine hairs. The leaf blade has oil glands, especially on the upper surface of the leaf base. It has a leaf stalk length ranging from 4.5-7 mm. Its flowers are arranged in umbrellas, which appear at the ends of branching branches. The flower adornment is white with a flower crown (petal) about 5-7 mm long. The fruit is oval in shape measuring 7.5-12 x 3.5-6 cm, purplish red. It has round seeds - oval measuring about 20 x 10 mm. The surface of the fruit has smooth brown hairs with a hard and thick endocarp skin. The fruiting period is in May-December every year (Prance, 1989).

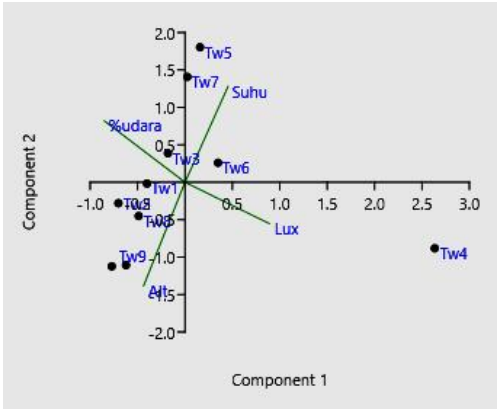


Figure 4. Ordination graph of PCA analysis results on environmental factors where quarterly growth in Sempu Island NR. (Note: Alt = altitude, Suhu = temperature, %udara = humidity, Lux = light intensity)

In the exploration and flora research activities carried out by the Purwodadi Botanical Gardens at Sempu Island NR, several locations where *M. corymbosa* was found, were noted in the area showed in Figure 2. The purpose of plant exploration activities is to save plants that live in Indonesia, especially those that grow in the lowlands for ex situ conservation in the Purwodadi Botanical Gardens. From observations in the field, it is still relatively common to find this species of regeneration (seedlings, saplings). However, in this study, individual number of M. *corymbosa* was not calculated. Additional information about population of *M. corymbosa* was presented by Rindyastuti et al (2018). This species was found in Teluk Semut-Segoro Anakan route in the tree-form with density 11 trees/ha, frequency 0.33%, and important value 20.65 (Rindyastuti et al, 2018); whereas Danarto et al (2018) presented the value of *M. corymbosa* in the tree-form in northern coast of Sempu Island: density 7 trees/ha, frequency 4.88%, important value 40.35. Risna (2009) also presented the individual number of *M. corymbosa* in Sempu Island: 6 trees (Waru-waru), 4 trees (Air Tawar), 7 trees (Gua Macan), and 5 trees (Teluk Semut).

Lestari (2011) noted that *M. corymbosa* saplings were found growing in the Lamedai Nature Reserve, Kolaka, Southeast Sulawesi. This condition may indicate that this type of mature/tree strata also grows in the area and is a native species that grows naturally there. Research conducted by Nizar et al (2016) noted that the this species was also found growing in production forest areas in Donggala Regency, Central Sulawesi and has the potential as a wood-producing tree species. Saribanon et al (2020) stated that this type of regeneration is still commonly found growing in the forests of the coastal area of Banggai Regency, Central Sulawesi, as part of the composition of the primary forest ecosystem in the area. Laatung (2015) also explained that *M. corymbosa* was found growing in the Tangkoko Dua Sudara Nature Reserve, North Sulawesi.

In general, the presence of *triwulan* trees in Sempu Island NR is found growing on sandy and rocky soil substrates at an altitude of 20-56 m above sea level. From the results of the PCA analysis ordinance graph (Figure 4) it is known that the *triwulan* growing locations in Sempu Island NR generally have the character of being in the lowlands, with low light intensity (shaded), in cool or humid areas. There are 6 locations that have this kind of character, namely the location of Tw1, 2, 8, 9, 10 and 3. However, most of the *triwulan* encounter locations have the same habitat character, this can be seen from the position of the location points which are mostly located on the y-axis in the resulting ordinance graph. Only the Tw 4 location is separated from other locations. Thus, it can be concluded that most of the locations where *Maranthes corymbossa* grows in Sempu Island NR have the same character, namely in the lowlands, in locations with low light intensity or shaded places, in cool or humid areas. In this study, it is known that the light intensity (Lux) and humidity (%) factors are environmental factors where they grow which have a major influence on the presence of *Maranthes corymbossa*. The two environmental factors have eigenvectors values of 0.9525 and -0.913 (Table 2). The eigenvectors value is the coefficient of the combination of linear variables that compose a principal component analysis. As stated by Zervoudakis et al. (2012) that among the main environmental factors, light was the most important which controls photosynthesis,

and accordingly, plant survival, growth and adaptation. The value of relative humidity is an important environmental parameter for plant production because it affects the rate of leaf transpiration and can affect the water balance in plants (Chia and Lim, 2022). Usually, relative humidity is also affected by air temperature because changes in ambient air temperature will influence the water content in the atmosphere causing relative humidity to vary (Chia and Lim, 2022).

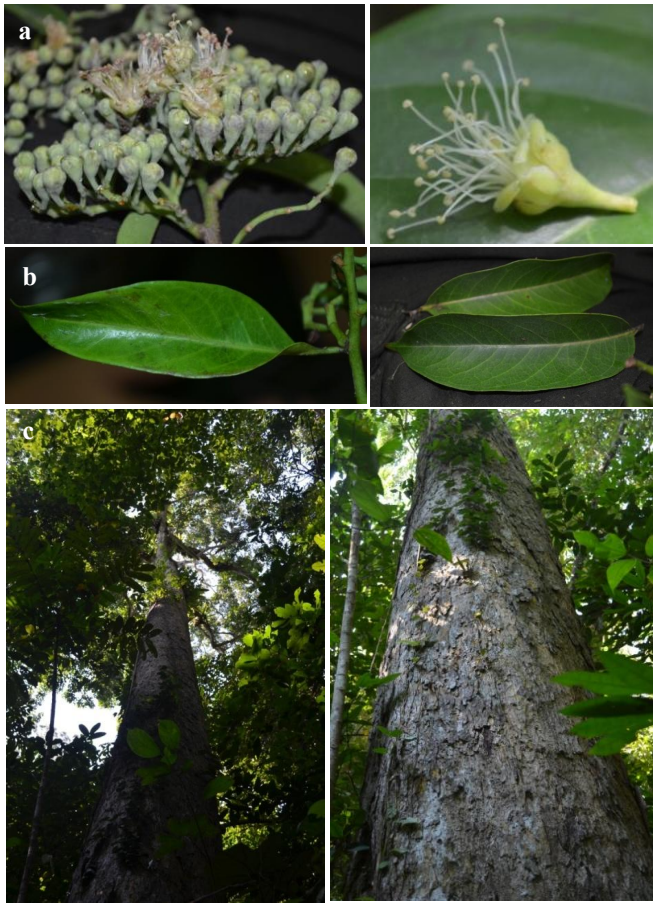


Figure 5. Morphological characters of *M. corymbosa*: a. inflorescence (left) and flower (right), b. leaves and c. trunk

M. corymbosa mostly found in Waru-waru (Table 1), i.e. 6 times of encounters, compare to other location: Telogo Lele two times, Teluk Semut ones and Segoro Anakan ones. Waru-waru is one of the beaches area on Sempu Island which has a stretch of sand flanked by rocky cliffs so it is classified into sandy and rocky beaches. This beach is the widest beach in the Sempu Island area. Telogo Lele is the name of a lake in Sempu Island that has ± 1 hectares area. Telogo Lele is an open area on Sempu Island and has moderately moist soil conditions because it is close to water sources. This area is dominated by pioneer vegetation and grass, but shrubs and seedlings are also found, while trees are rarely found. Teluk Semut is an area on Sempu Island that juts into and has a short coastline. This area has mangrove and coastal forest ecosystems. Segoro Anakan is a rocky and corally beach area located on the south coast. This area includes an area of steep limestone hills and gently sloping sandy beaches. According to data recorded by WCMC (1998), this species was found in areas of primary and secondary forest, from sea level to 1,500 m. More information from Slik (2009), this species was naturally found in mixed dipterocarp forests up to 1700 m altitude, commonly along rivers and on alluvial sites, but also common on hillsides and ridges on sandy soils, and sometimes on limestone. Thus, it can be said that the habitat range of *M. corymbosa* is quite wide; from coastal areas, lowland forest until montane forest. In this study, *M. corymbosa* was more commonly found in coastal forests in the lowlands with humid air. Referring to data from the Global Biodiversity Information Facility (GBIF, 2019), it is known that *M. corymbosa* grows naturally in the southern part of Thailand, the Malay Peninsula, the Indonesian Archipelago, Caroline Island in the Australian Tropics to the Solomon Islands in the Pacific. This species was also found in Panama, Central America. This species is usually found in monsoon forest and coastal forest, riparian forest, vegetation in open areas, and in sandy coastal forest vegetation up to an altitude of 1,500 masl. It can grow in various soil substrate conditions such as rocky granite soil, sandy soil, humus soil, clay soil and even lateritic soils with a fairly high metal content (Anonym, 2013; Prance, 1989; Anonym, 2020). Figure 6 shows the distribution of *M. corymbosa* all over the world.

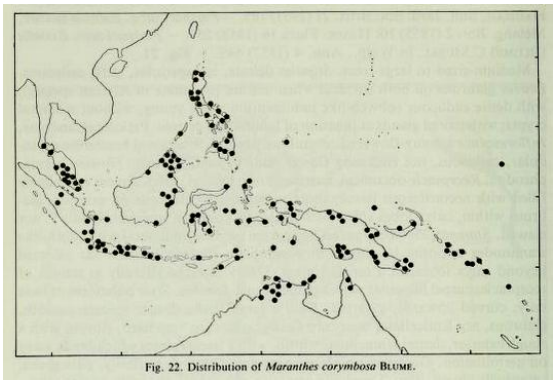


Figure 6. Distribution map of *M. corymbosa* (Prance, 1989)

Triwulan Conservation Effort

Based on the IUCN Redlist (World Conservation Monitoring Center/WCMC, 1998), *Maranthes corymbosa* has a lower risk (LR) conservation status or Least Concern (lc) (Figure 7). *Maranthes corymbosa* has a conservation status that is not classified as threatened, meaning that its existence in nature is still relatively well preserved. Nevertheless, the danger of threats will still exist along with the increase in the use of wood and the current rate of forest destruction. The high rate of destruction of lowland rainforest ecosystems can be an indication of the threat of diminishing natural habitat for this species. On the other hand, the community's need for wood also continues to increase. These two things are likely to change their conservation status to a higher level so they need special attention to prevent them from becoming extinct. Moreover, the conservation status of this species requires a new assessment, because the last data related to its conservation status was published in January 1998 (WCMC, 1998) so it is necessary to reassess the conservation status of this species.

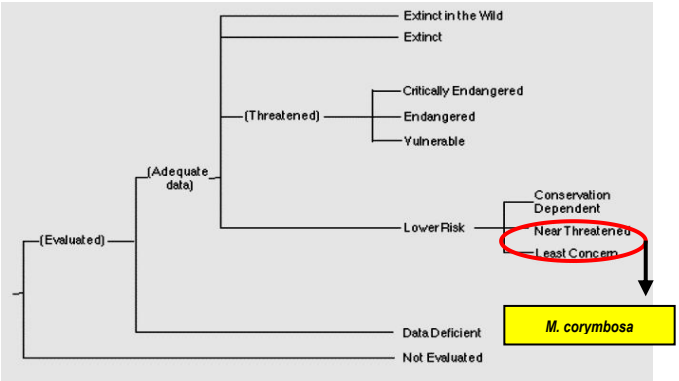


Figure 7. Grouping the conservation status of a species (*Maranthes corymbosa*)

As a form of conservation effort, the Purwodadi Botanical Gardens has collected this species ex-situ. The collection plants were planted in plots XV.C.12-12a (Figure 8) (Irawanto et al, 2015). The collection comes from Sempu Island which was originally collected in the form of seedling, with collector number (MAR 24) in March 1994. It has been registered and registered at Purwodadi Botanical Gardens with access number P19940324 and planted as a collection on December 7, 1994. Thus the collection in the garden is about 22 years old. The collection plant height reaches 5 meters with a stem diameter of 8 cm (Figure 4). Finagen et al (1999) stated the results of their research conducted in Costa Rica that the Chrysobalanaceae group (including the genera Maranthes, Couepia, and Hirtella) is a slow-growing tree species. Plant seed material in the form of saplings from the results of this study is an additional collection for the Purwodadi Botanical Gardens.

The collection of this species has also been conserved ex-situ by the Bogor Botanical Gardens and Cibodas Botanical Gardens. A total of 3 collection plants have been collected at Bogor BG from Java and Maluku. Meanwhile, at Cibodas BG, there were 1 collection number from South Sulawesi (Ariati et al, 2019; Sujarwo et al, 2019).

By knowing its natural distribution, it will be easier to conserve this species, at least by protecting the areas where it grows as an in situ conservation area. Sempu Island Nature Reserve is one of the conservation areas that protects the existence of this species naturally. Likewise, the Lamedai Nature Reserve in Southeast Sulawesi (Lestari, 2011) and the Tangkoko Dua Sodara Nature Reserve in North Sulawesi (Laatung, 2015). Given that this species is a slow-growing species, conservation efforts can also be carried out outside its natural habitat, as was the case in the Purwodadi Botanical Gardens. Efforts to maintain and multiply it can be done to help its existence and sustainability. The presence of *Maranthes corymbosa* trees in the Sempu Island NR can be a source of seeds. This will certainly support the propagation and conservation of this species. Information about the flowering and fruiting seasons can be used as a basis for further observations and research to collect seeds in the field.

Efforts to propagate this species can actually be done to maintain its existence in nature. Naturally rejuvenation is done by using the seeds. The germination of the seeds does not require special treatment and can be sown directly in the sun. Seeds will start to germinate after 27-30 days after sowing with the growth percentage can reach 80% after 51-82 days of sowing. Planting seedlings in the field can be done after reaching a height of 15 cm or after about 5 months old. The fruiting period occurs in July – October and the fruit ripening period occurs in September – December. Treating seeds as a source of seeds can be done by drying (to reduce moisture content) and stored in a closed place. Seed viability can last for 3 months. In 1 kg of kolaka seeds there are approximately 330 seeds (Anonym, 2016b).

Clark et al (2009) stated that in the Northern Territory of Australia, experiments were carried out in planting several tree species in the form of plantations, one of which was *M. corymbosa*. From the experimental results, it is known that after 47 months of planting this species has a fairly high percentage of life (96.3%), with an average height dimension of 2.83 meters and 2 cm dbh.

Maranthes corymbosa is one of the plants that grows naturally in Sempu Island NR. Its existence is still relatively well maintained because it grows in a conservation area. It can be found naturally in the lowlands, with low light intensity or shaded places, and

have humid environmental conditions. The potential benefits of this species are quite large, both for commercial use of the wood or for providing benefits to the environment and ecosystem. Conservation efforts for this species need to be carried out considering the pressure on its existence is quite large due to logging and changes in its natural habitat.

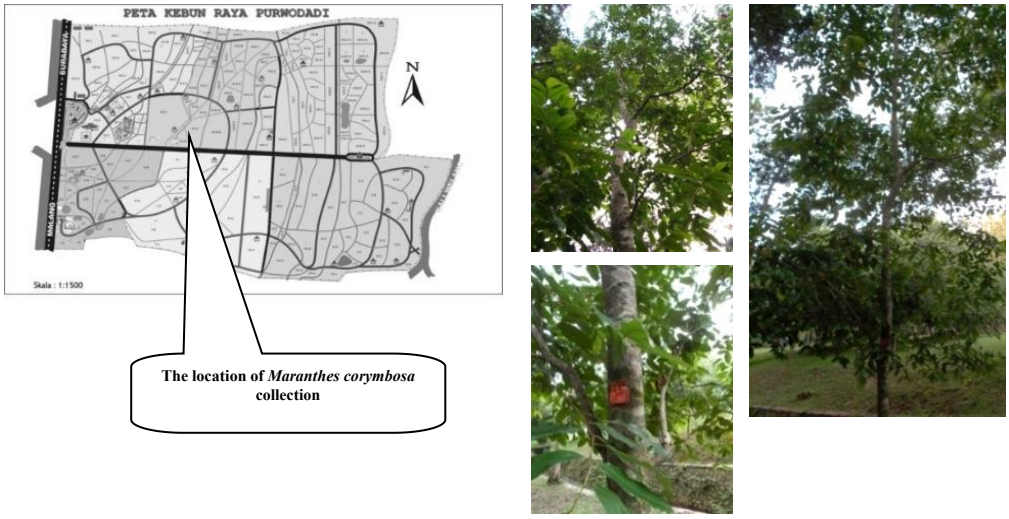


Figure 8. Location and plant collection of *Maranthes corymbosa* at Purwodadi Botanical Gardens

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