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Adult mangrove stand does not reflect the dispersal potential of mangrove propagules: Case study of small islets in Lampung, Sumatra

AGUNG SEDAYU♥, NOVITA FARAH ISYADINYATI, DIANA VIVANTI SIGIT
Department of Biology, Faculty of Mathematics and Natural Sciences, State University of Jakarta. Jl. Pemuda 11 Rawamangun, East Timur 13220, Jakarta, Indonesia. Tel. +62-21-4894909. Fax. +62-21-4894909. ♥email: goeng93@yahoo.com

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Abstract. *Sedayu A, Isyadinyati NF, Sigit DV. 2011. Adult mangrove stand does not reflect the dispersal potential of mangrove propagules: Case study of small islets in Lampung, Sumatra. Nusantara Bioscience 4: 57-61.* Most mangrove species are dispersed by water current with distance being a major constraint. We tried to demonstrate that distance is indeed the dispersal limiting factor in mangrove, and perhaps other marine plant species. Secondly, we also tried to clarify whether landmass is a real blockade for mangrove dispersal. Lastly, we argued that in order to study plant dispersal potential, one should not study the later stage of plant population, as normally plant ecologist would do, rather at their early life stage. Cluster analyses were used to test those hypotheses and confirmed our research hypotheses.

Key words: biogeography, dispersal, mangrove, propagules.

Abstrak. *Sedayu A, Isyadinyati NF, Sigit DV. 2011. Tegakan mangrove dewasa tidak mencerminkan potensi penyebaran propagul mangrove: Studi kasus pulau-pulau kecil di Lampung, Sumatera. Nusantara Bioscience 4: 57-61.* Sebagian besar jenis mangrove tersebar oleh arus air dengan jarak sebagai kendala utamanya. Penelitian ini mencoba untuk menunjukkan bahwa jarak menjadi faktor pembatas dalam penyebaran mangrove, dan jenis tumbuhan pantai lainnya. Kedua, penulis juga mencoba untuk mengklarifikasi apakah daratan adalah secara nyata membatasi penyebaran mangrove. Terakhir, penulis memperdebatkan bahwa untuk mempelajari potensi dispersal tumbuhan, seseorang tidak harus mempelajari tahap akhir dari populasi tanaman, sebagaimana banyak dilakukan para ahli ekologi tumbuhan, namun dapat pula pada tahap awal kehidupannya. Analisis klaster digunakan untuk menguji hipotesis tersebut dan dikonfirmasi dengan penelitian ini.

Kata kunci: biogeografi, penyebaran, mangrove, propagul.

INTRODUCTION

Coconut tree, most probably originally from Polynesia-Melanesian, is naturally distributed pantropically on most beach areas, with the help of its floatable fruits. However, being an ethnobotanically ancient important crop, its limited distribution range in some places like South America, especially Panama, is mostly caused by pre-industrial human migration (Ward and Brookfield 1992). On the other hand, mangrove, with similar dispersal capability, had no economic importance to prehistoric human, hence their almost identical worldwide distribution to coconut tree is solely attributed to their own capability to colonize adjacent area

Many of mangrove species are known to spread by floatable propagules. Some propagules, such as in *Rhizophora,* are dispersed by viviparous seed/embryo,; while others with their floatable non-viviparous fruits/seeds. The survival, including dispersal, recruitment and growth of the propagules depends on many inherent (genetic traits) and external (environmental) factors.

Initial propagule characters such as weight, shape, orientation, time of shoot emergence, and buoyancy, and early growth, such as (time??) and numbers of plants with initiated roots and shoots are important traits determining the dispersal and recruitment of mangrove species along tidal area (Rabinowitz 1978a, b). These traits interact with external/environmental factors, such as salinity, water turbulence, water depth, temperature, tidal amplitude, water current and light exposure, disturbance, predatory and competition (McMillan 1971; Smith and Duke 1987; Osborne and Smith 1990; Jimenez and Sauter 1991; Sousa et al. 2007). The interaction of such factors has resulted in the existing mangrove population stands along the pantropic.

For tidal species, water current and distance from mother tree (genetic source or original population) are particularly important in propagule dispersal. For land plants, water bodies such as seas, lakes, oceans or rivers act as physical barriers of natural distribution. On the contrary, for mangroves, landmasses virtually act as physical barriers of their distribution.

Using the natural mangrove stands at differing life stages at Teluk Lampung, Sumatra, we aimed to (i) understand the dispersal potential of mangrove species in terms of predicting the long distance travel of propagules from bigger island to smaller satellite islets and confirming whether the landmass are actual dispersal barriers for mangroves; (ii) test which life stages of mangroves (seedling, sapling and tree) are best to detect the mangrove dispersal potential.

MATERIALS AND METHODS

Six stations on the western coast of Lampung had been chosen for this study. Two of which, Suamalu (05.724° S, 105.207° E) and Kalangan (05.645° S, 105.207° E) are situated on the coast of main Island, Sumatra, while the other four are on two small islets just across the former two. Two stations are situated at Puhawang islet with one station (Puhawang Barat; 05.674° S, 105.207° E) is facing directly toward Sumatra and the other one (Puhawang Timur; 05.672° S, 105.235° E) facing Sunda Strait. The last two stations are situated at Kelagian islet, with one station (Kelagian 05.630° S, 105.213° E) is facing Sumatra and the other one (Goreng; 05.617° S, 105.222° E) facing Sunda Strait (Figure 1.). At each station, a line transect was set from the sea, landward, starting from where the outermost mangrove stands was located. The length of transects depended on how thick the mangrove stand was, about 60 m to 100 m each.

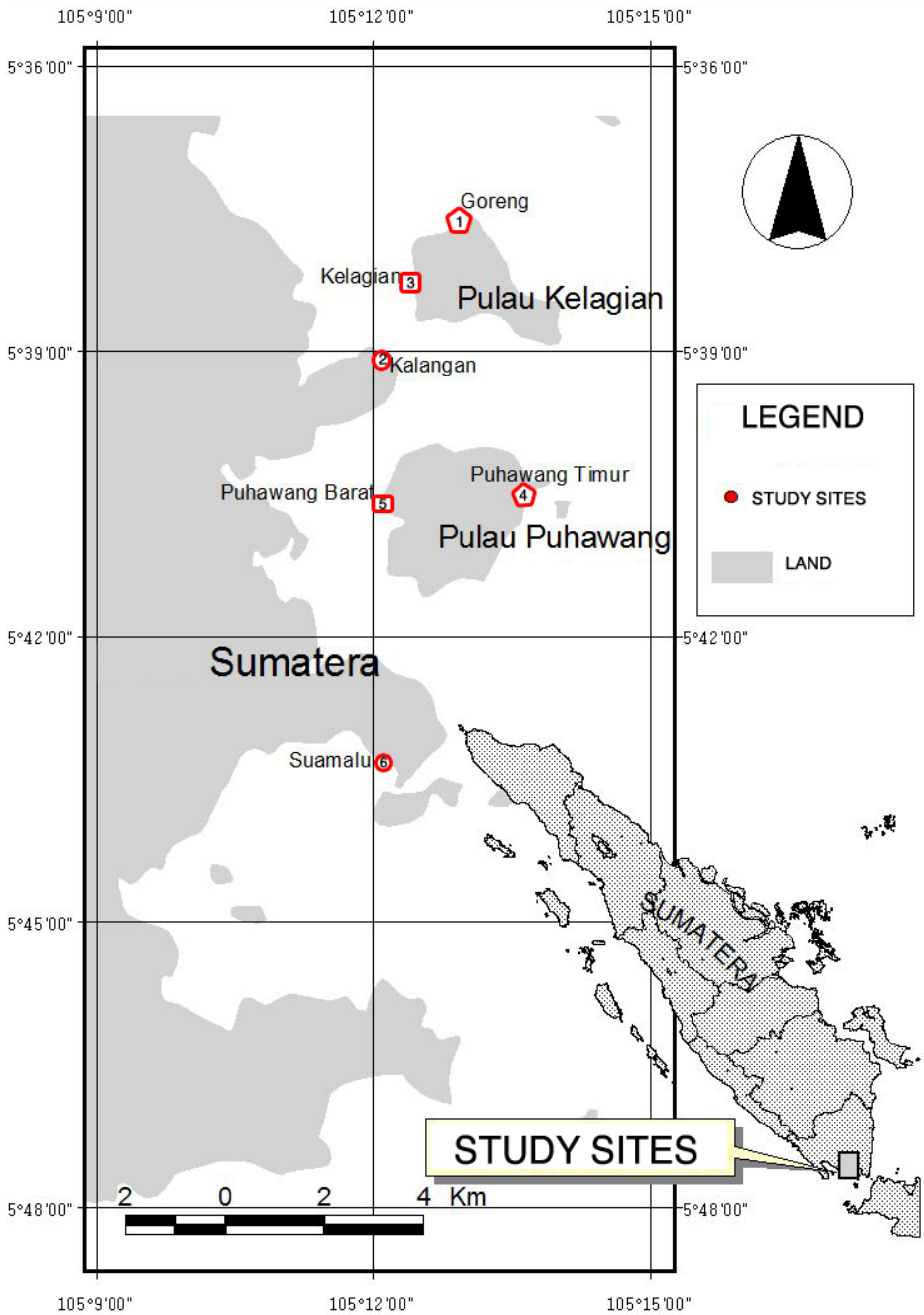

Figure 1. The study sites in Teluk Lampung; the symbols on each site depict their relative similarity as depicted in Figure 2.

At each transect, three nested quadrates were laid, the smallest one, 1 x 1 m, was designated for seedlings, the 5 x 5 m quadrate for saplings and the 10 x 10 m for trees. We counted for each quadrate the number of species, frequency and basal area in order to calculate the importance value of each species (Cox 1972). For identification, specimens of unknown individuals were taken and once identified were kept at the herbarium of UNJ (JUNJ). Data from each transects were treated as one to portray each station as one entity, therefore there were six figures of importance values of all species surveyed representing six stations, thus assembling a matrix of 6 x number of all species (Table 2). The matrix was analyzed for its similarity index, using program *PRIMER (Plymouth Routines in Multivariate Ecological Research)* version 5.1.2., and the results were drawn as dendrograms.

RESULTS AND DISCUSSION

Three dendrograms were produced representing three life stages of mangrove, seedling, sapling and tree. Figure 2A shows that the tree similarity indexes between sites is almost incongruous in the biogeographical point of view, since each site does not reflect its close affinity based on geographical distances. The mangrove on the furthest south site on Suamalu, which is located in Sumatra is the closest according its importance value similarity index to our northernmost site at Goreng on Pulau Kelagian. In the sense of biogeography, the closer the areas, the more similar their species component. Trees tend to form random stands, without a distinct pattern between places.

The sapling data plotted on figure 2B shows a distinct cluster between Kelagian at Pulau Kelagian and Puhawang Barat at Pulau Puhawang. Kelagian which is located on the closest end of Pulau Kelagian to Sumatra which has a distinct similarity with Puhawang Barat, which is also located at the closest end of Pulau Puhawang to Sumatra. Other study sites are clumped together in an above cluster, consisting of four sites, however with unclear information with regards to its geographical position.

The seedling data on Figure 2C showed two big clusters, each forming an interesting grouping where sites on small islets adjoining the bigger main island (Sumatra) have the greatest similarity index, as well as those distal to Sumatra. The sites on Sumatra are not joined, interestingly, to each other, but clusters to sites facing the main island or afar from the main island.

Table 1. Composition of species in combined study areas.

Family	Species	Composition (%)
Bombacaceae	*Camptostemon schultzii*	0.36
Euphorbiaceae	*Excoecaria agallocha*	0.12
Meliaceae	*Xylocarpus granatum*	0.36
Rhizophoraceae	*Bruguiera cylindrica*	2.65
	Bruguiera gymnorrhiza	4.45
	Ceriops tagal	6.5
	Rhizophora apiculata	58.24
	R. x lamarckii	16.97
	R. mucronata	7.7
Sonneratiaceae	*Sonneratia alba*	2.65
		100

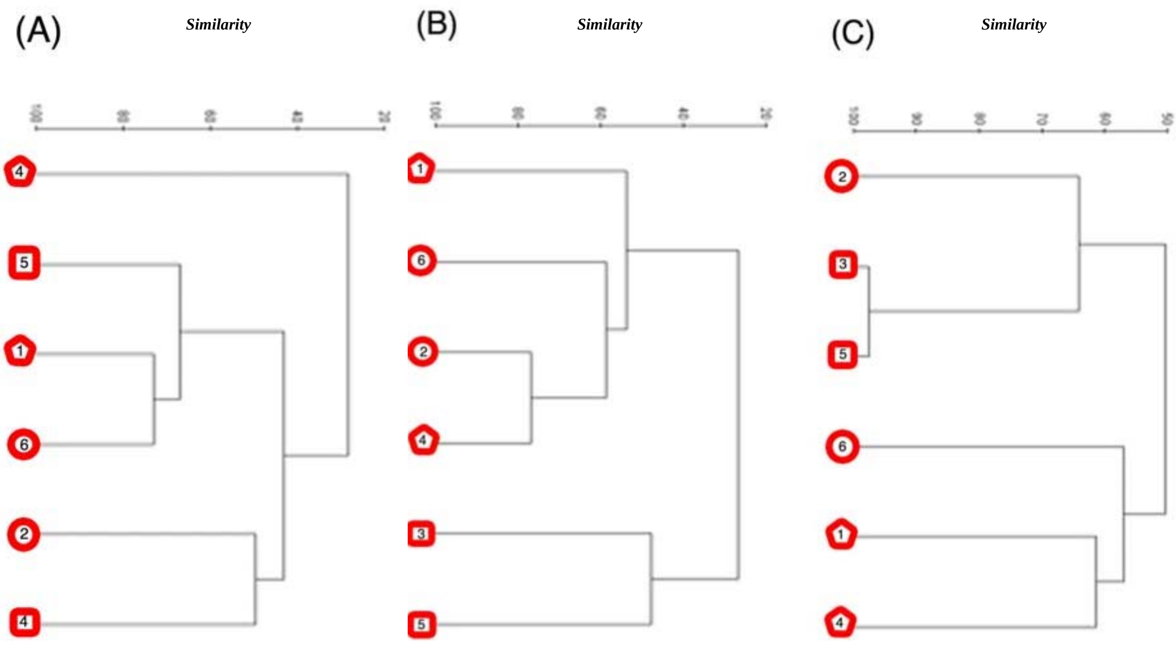

Figure 2. The dendrogram of similarity between sites; (A) Tree; (B) Sapling; (C) Seedling. For information about symbols and names of places see Figure 1.

Table 2. Importance values of each mangrove species matrix.

Species	Kelagian			Puhawang Barat			Puhawang Timur			Suamalu			Goreng			Kalangan		
	Tr	Sa	Se	Tr	Sa	Se	Tr	Sa	Se	Tr	Sa	Se	Tr	Sa	Se	Tr	Sa	Se
Bruguiera cylindrica	27.1	32.08	45	0	0	0	0	0	0	0	27.8	0	0	0	0	0	0	0
Bruguiera gymnorrhiza	40.8	45.8	84.4	32.23	0	23.01	0	0	0	0	0	0	0	0	0	65	17.71	0
Camptostemon schultzii	16.44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceriops tagal	0	34.7	28	0	43.17	17.35	0	0	0	0	21	78.65	0	0	0	0	19.33	158
Excoecaria agallocha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.9	0
Rhizophora apiculata	162.8	75.5	129,75	160.1	184.4	211	49.9	300	261.2	164.4	177.9	221.3	50.85	148	49	0	238	142
Rhizophora mucronata	0	27.34	0	107.6	72.42	47.91	0	0	0	61.5	43.6	0	0	0	0	0	0	0
Rhizophora x lamarckii	23.4	71.14	12.88	0	0	0	250.1	0	38.8	0	0	0	180	120.6	251	235	0	0
Sonneratia alba	29	0	0	0	0	0	0	0	0	62.3	29.7	0	68.31	31.4	0	0	0	0
Xylocarpus granatum	0	12.96	0	0	0	0	0	0	0	11.3	0	0	0	0	0	0	0	0

Note: Numbers are in percentage (%); Sa: Sapling; Se: Seedling; Tr: Tree.

All species within our study area are species with floatable propagules. Rhizophoraceae (*Rhizophora* and *Bruguiera*) are species with highest important values, and the most common in all sites (Table 1 and 2), are equipped with viviparous propagules. Other species seed types are not viviparous, but buoyant. *Sonneratia* has edible arillate fruits known being eaten by bats and macaques, but the dispersal mode of this species is solely by floating, since the fruit has outer floatable tissue and too big to be swollen in whole. *Excoecaria agallocha* and *Xylocarpus granatum* have exploding capsules and fruits, and the shooting seeds which also have buoyancy potential. *Camptostemon schultzii* has floatable a capsule which, when splits, releases the seeds, having potential to disperse by water as well as wind (Noor et al.1999). We did not test whether the viviparous species thrives more successfully compared to the non-viviparous species, but this character seems to be a crucial feature in determining why species of Rhizophoraceae (all with viviparous fruits in our study site) were much more common in all three life stages surveyed. Other investigators such as Smith and Sneadaker (2000) confirmed that the vivipary of Rhizophoraceae has a significant effect on its distribution along tropical and subtropical coastal areas. This explains why viviparous species is much more common than non- viviparous species, although they have similar means of distribution, water floatable propagules. Traits related to establishment were stronger predictors of distribution than those associated with dispersal (Clarke et al. 2001).

The distance between sites is the best explanation of the pattern shown in Figure 2.C., where the location adjacent to genetic source (i.e. bigger landmass, like Sumatra) has the largest similarity to that landmass, where the propagules presumably originated. Clarke (1993) observed that propagules of *Avicennia marina* was best transplanted within only 500 m afar from its point of release (mother tree), and the success slightly decreased at a distance of 1 km and was the least at 10 km, resulting restricted gene variation between populations and very slow recovery when mass mortality occurred. That explains why the sites distal to Sumatra landmass had much different importance values from those proximal to Sumatra. The immigration of mangrove propagules to sites secluded by land (i.e. opposing the small islets), from the genetic source is inevitably much lower, as the landmass acts as physical barrier for the water transported propagules (Duke et al. 1998).

In both tree and sapling dendrograms (Figure 2 A, B), the pattern of dispersal potential of mangrove by water current is not obvious. In fact, the dendrograms produced in Fig. 2 A is almost illogical. In the Figure 2 B, at least the locations distal to Sumatra (Kelagian, 3 and Puhawang Barat, 5) are grouped in one cluster, showing that seedlings in those areas have higher similarity in species importance values, however the rest of clustering give no information in terms of biogeographical distribution of mangrove species. Both irrelevant dendrograms most likely reflect the later development of each mangrove population. Saplings and especially trees suffer from longer period of both inherent, genetic and environment pressures. Pinzon et al.(2003) demonstrated that natural mortality, human-induced mortality, diseases and natural predations produce gaps in natural population (Osborne and Smith 2003).

This research study implies that biogeographical studies focused on plant dispersal potential should focus at the plant's early stages, when stands of juveniles are less likely affected by environment, competition, predation or habitat modification, leading to individual mortality. Analysis for such purposes with later stages of plant development as sapling and tree may introduce bias in the analysis, as those stages are exposed to many factors leading to mortality for a longer period of time, hence afflicting the distribution of plants in a certain site.

CONCLUSIONS

Most mangrove species are dispersed by water current with distance as a major constraint. We tried to demonstrate that distance is indeed the dispersal limiting factor in mangrove, and perhaps other marine plant species. Secondly, we also tried to clarify whether landmass is a real blockade for mangrove dispersal. Lastly we argued that in order to study plant dispersal potential, one should not study the latter stage of plant population, as normally plant ecologist would do, rather at their early life stage. Cluster analyses were used to test those hypotheses and confirmed our research hypotheses.

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