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Abundance and Distribution of Medicinal Plants in Madapi Forest Kerinci Seblat National Park (KSNP) Rejang Lebong, Bengkulu

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ABSTRACT
Kerinci Seblat National Park (KSNP) as a conservation area posses a strategic role as a source of medicinal plants. This research on the potential of medicinal plants as one of Non-Timber Forest Products (NTFPs) in the MADAPI Forest in Rejang Lebong Region of KNSP, in Bengkulu Province, aimed to determine the species richness, abundance, and spatial distribution of medicinal plants in the forest. This research is important to find out the potential of KSNP in providing medicinal plants. Sampling of plants was conducted in 80 plots, each measuring 20x20m in four sections of MADAPI Forest. From 80 plots, 33 species of medicinal plants were found, representing 27 families. Mostly the plants were herbs and the most dominant families found in the sites were Asteraceae and Moraceae. Based on its relative abundance, all of medicinal plant species were categorized as rare with clumped distribution; only a few species were spread randomly or uniformly.

Keywords: *abundance, distribution, MADAPI Forest, medicinal plants*

1. INTRODUCTION

Kerinci Seblat National Park (KSNP) located in Sumatra is the largest national park in Southeast Asia, named as the ASEAN Heritage National Park. Since the park has a very high biodiversity of both flora and fauna, it is designated as a part of the Tropical Rainforest Heritage of Sumatra (TRHS) and as a world heritage site by the World Heritage Committee [1]. KSNP covers four provinces, namely West Sumatra Province (353,780ha), Jambi Province (422,190ha), Bengkulu Province (310,910ha), and South Sumatra Province (281,120ha) [2]. In Bengkulu Province, KNSP is spread in four districts namely Rejang Lebong, Lebong, North Bengkulu, and Muko-Muko. The MADAPI forest is located within the KNSP Rejang Lebong, Bengkulu which is composed of four main sections with three dominant tree species of KNSP namely *Swietenia mahagoni* (L). Jacq. (mahagony/mahoni in Indonesia), *Agathis dammara* (Lamb.) Rich.(resin tree/damar), *Pinus merkusii* Jungh. & de Vriese (pine/pinus), and another species, i.e. *Aleurites moluccana* (L.) Willd. (candlenut/kemiri).

Recently, illegal exploitation of the KSNP conservation area, especially in Rejang Lebong District in the form of illegal logging and land encroachment for coffee plantations has increased intensively. This causes ecological damages that disrupt the strategic function of KSNP as carbon storage, oxygen provider, and regulator of water systems, primarily for the surrounding area. This illegal exploitation will also have an impact on the availability of medicinal plants [3]. According to Government Regulation No. 108/2015, a national park as a conservation area can have a certain zone which can be managed and utilized by the local community to get non-timber forest products (NTFPs) i.e. food plants, medicinal plants, latex, bamboo, rattan, and others [4]. Several studies identifying medicinal plants in national parks have been carried out, such as Fachrurozi [5] in the Gunung Gede National Park who found 45 species, and Zulnely et al [6] identified 20 species of medicinal plants in Mount Halimun Salak National Park. Research of medicinal plant diversity in KSNP has been carried out by Susatya [7] who found 16 families and 54 species that potential to be used as anti-cancer drugs, while 10 families and 37 species contained substances potential to be used against HIV.

This study was carried out to determine the species richness, abundance, and distribution of medicinal plants in MADAPI Forest. The data from this study will be useful for the conservation of existing NTFP species in KNSP.

2. MATERIALS AND METHODS

2.1 Study area

The study was carried out from April to October 2019 in MADAPI Forest Kerinci Seblat National Park Rejang Lebong, Bengkulu. The area located in Rejang Lebong District, approximately 100 km from Bengkulu City, the capital of Bengkulu Province, Indonesia, in the southern part of Sumatera region (102°28'12" – 102°29'24" E and 03°21'00" – 03°22'12" S with altitudes ranging from 900 to >1000 m. The daily temperature varies from 16°C to 32°C. The mean annual rainfall ranges from 1600 to 4000 mm per year. The MADAPI Forest area is 212.807 hectares which divided into four sections namely *Swietenia mahagoni* area (31.650ha), *Agathis dammara* (21.521ha), *Pinus merkusii* (148.796ha), and *Aleurites moluccana* ((10.840 ha). The study site is shown in Figure 1.

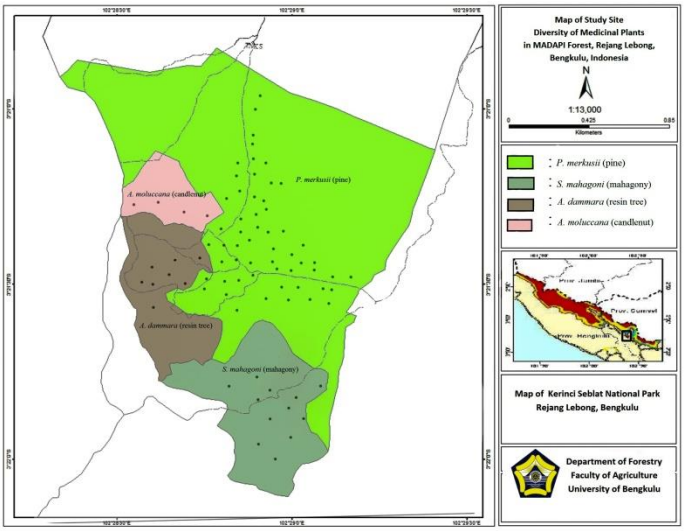

Figure 1. Plot distribution of the study site

2.2 Procedures

Sampling was conducted in four different sections with a total of 80 plots, each measuring 20x20 m: *S. mahagoni* (12 plots), *A. dammara* (8 plots), *P. merkusii* (56 plots), and *A. moluccana* (4 plots). Within each plot, the local names, number of individual plants, and life forms of each plant were recorded. Three local eguides who have good knowledge of the local medicinal plants assisted to identify the plants. The scientific names were identified by using books of the flora of Sumatera in the laboratory and some references on the internet. Herbarium specimens of some medicinal plants were collected in the laboratory.

2.3 Data analysis

Species abundance was determined using the formula of Mahajan and Fatima [8]) using the equation as following:

$$\text{Density} = \frac{\text{total number of individual of the species}}{\text{total number of plot}}$$

$$\text{Relative Density (RD)} = \frac{\text{density of a given species}}{\text{total density of all the species}} \times 100\ \%$$

The abundance type is categorized as RD 1 -20%: rare
RD 21-40%: occasional
RD 41-60%: frequent
RD 61-80%: common
RD 81–100%: abundant

Spatial distribution of the species was calculated by using Index of Dispersion (ID) or variance to mean ratio (VMR) [9]

$$\text{Variance} = \frac{\Sigma f\,(x - \overline{x})2}{N - 1}$$

$$\text{Mean} = \Sigma f\,(x)/N$$

$$\text{ID or VMR} = \frac{\text{Variance}}{\text{Mean}}$$

where: f = observation plot
x = number of individual of a species
$\overline{x}$ = sample mean
N = number of plot

If VMR <1: random distribution pattern
VMR =1: uniform distribution pattern
VMR >1: clump distribution pattern

3. RESULTS AND DISCUSSIONS

3.1 Species richness and abundance of medicinal plants

Table 1 shows the species composition of the medicinal plants, their families, and life forms in the study sites. Asteraceae and Moraceae were the dominant families in all the sites. *P. merkusii* section had the highest number of individuals and *A. moluccana* section the least. *Clidemia hirta* was the most common species in P. *merkusii* stands (168), followed by *Diplazium esculentum* /ferns (92) and *Erechtites valerianifolius* (80). In the A. *dammara* section, the most dominant species was *Clidemia hirta* (63), followed by *Diplazium esculentum* (41) and *Lantana camara* (30). In the S. *mahagoni* area, it was dominated by *Swietenia mahagoni (*16) and *Diplazium esculentum* (68). In A. *moluccana* section was dominated by *Diplazium esculentum* (120), followed by *Etlingera elatior* (98) and *A. moluccana* (58). Some plants were found only in certain areas, such as *A. moluccana, Psidium guajava* , and *Syzygium malaccensis* were found in A. *moluccana* section; *Alstonia scholaris* and *Artocarpus altilis* in S. *mahagoni* section, and *C. odorata* and *Ficus benjamina* in the A. d*ammara* section. The medicinal species that only found in the P. *merkusii* section was *Andrographis paniculata*, *Asplenium nidus*, *Ceiba pentandra*, *Eurycoma longifolia*, *Ficus septica* , and *Trema orientalis*.

Table 1. Species composition of the medicinal plants at the study sites

#	Species	Family	Local Name	Number of the plant in the MADAPI Forest sections				Total	Lifeform
				S. mahagoni	*A. dammara*	*Pinus merkusii*	*A.moluccana*		
1	*Ageratum conyzoides* L.	Asteracecae	Bandotan	-	20	30	-	50	Herb
2	*Aleurites moluccana* (L.)Willd	Euphorbiaceae	Kemiri	-	-	-	58	58	Tree
3	*Alstonia scholaris* (L). R. Br.	Apocynaceae	Pulai	1	-	-	-	1	Tree
4	*Alternanthera sessilis* (L.) R.Br. ex DC.	Amaranthacecae	Keremah	-	11	7	-	18	Herb
5	*Andrographis paniculata* (Burm.f.) Nees	Acanthaceae	Sambioloto	-	-	2	-	2	Herb
6	*Artocarpus altilis* (Parkinson) Fosberg	Moraceace	Sukun	3	-	-	-	3	Tree
7	*Asplenium nidus* L.	Aspleniaceae	Paku sarang burung	-	-	3	-	3	Herb
8	*Bambusa multiplex*	Poacecae	Bambu	4	-	18	1	23	Shrub
9	*Ceiba pentandra* (L.) Guerto	Bombacaceae	Kapuk	-	-	3	-	3	Tree
10	*Centella asiatica* (L.) Urban	Apiaceae	Pegagan	-	-	64	-	64	Herb
11	*Chromolaena odorata* (L.) R.M.King & H.Rob.	Asteraceae	Kirinyu	-	20	-	-	20	Herb
12	*Clidemia hirta* (L.) D. Don	Melastomaceace	Keduruk	3	63	168	13	247	Shrub
13	*Coffea* sp.	Rubiaceae	Kopi	-	20	63	-	83	Shrub
14	*Curculigo latifolia*	Hypoxidaceae	Singkut	-	-	4	-	4	Herb
15	*Diplazium esculentum* (Retz.) Sw.	Athyriaceae	Pakis	68	41	92	120	321	Herb
16	*Dracontomelon dao* (Blanco) Merr. & Rolfe	Anacardiaceae	Sengkuang	20	-	-	-	20	Tree
17	*Erechtites valerianifolius*	Asteracecae	Sintrong	4	20	80	2	106	Herb
18	*Etlingera elatior* (Jack) R.M. Smith	Zingiberaceae	Kecombrang	-	-	-	98	98	Herb
19	*Eurycoma longifolia* Jack	Simaroubaceae	Pasak Bumi	-	-	2	-	2	Shrub
20	*Ficus benjamina* L.	Moraceae	Beringin	-	1	-	-	1	Tree
21	*Ficus septica* Burm. F.	Moraceae	Awar-awar	-	-	4	-	4	Tree
22	*Flagellaria indica* L.	Flagellariaceae	Rotan	13	8	20	-	41	Shrub
23	*Homalomena cordata* Schott.	Aracecae	Keladi hutan	5	4	10	-	19	Herb
24	*Imperata cylindrica* (L.) P.Beauv.	Poacecae	Alang-alang	24	4	4	-	32	Herb
25	*Lantana camara* L.	Verbenaceae	Tembelekan	-	30	3	-	33	Shrub
26	*Melastoma malabathricum* L.	Melastomaceace	Senduduk	-	-	19	-	19	Shrub
27	*Piper betle* L.	Piperaceae	Sirih	1	4	14	2	21	Shrub
28	*Psidium guajava* L.	Myrtaceace	Jambu Biji	-	-	-	1	1	Tree
29	*Pyrrosia piloselloides* (L.) M.G. Price	Polypodiaceae	Sisik naga	-	-	4	5	9	Herb
30	*Solanum torvum* Sw.	Solanaceace	Terang	1	3	9	-	13	Shrub
31	*Swietenia mahagoni* (L.) Jacq.	Meliaceae	Mahoni	167	-	-	-	167	Tree
32	*Syzygium malaccensis* (L.) Merr. & Perry	Myrtaceae	Jambu Bol	-	-	-	1	1	Tree
33	*Trema orientalis* (L.) Blume	Cannabaceae	Anggrung	-	-	9	-	9	Tree
	TOTAL			314	249	632	301	1496	

Figure 2 displays the life form of medicinal plants. These results are the same as the findings in many other studies which also reported that medicinal plant species generally have habitus herbs, trees, and shrubs [10, 11, 12, 13].

There were 27 families of the medicinal plants found on the MADAPI Forest (Figure 3).. The most dominant family was Asteraceae (3 species), Moracecae (3 species), Poraceae and Myrtaceae were 2 species each. One species of Asteraceae, *Chromolaena odorata* was the most abundant. This species is common medicinal plants in Thailand and widely distributed in the tropics region [14]

Table 2 shows the abundance of medicinal plants from the each section. The most abundant species in the sites were *D. esculentum* and followed by *C. hirta, C. odorata, S. mahagoni, E. valerianifolius, E. elatior, Coffea sp., C. asiatica, A. moluccana*, and B. *multiplex.* However, all the species had an abundance percentage <20% and categorized as rare.

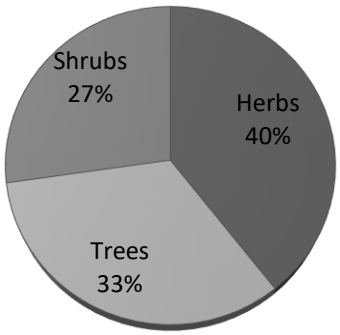

Figure 2. The life form of the medicinal plants in the MADAPI Forest

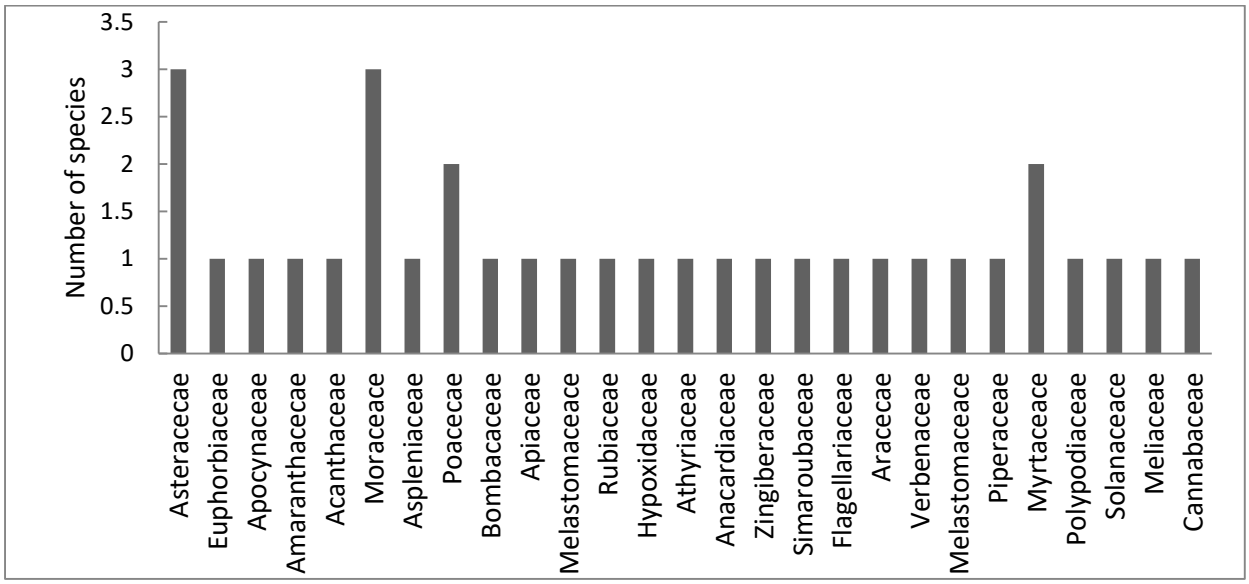

Figure 3. The family of the medicinal plants in the MADAPI Forest

The 1496 individual plants found representing 33 species and 27 families in MADAPI forest is less than the findings by Susatya [7] in Kerinci Seblat National Park that found 54 species and 16 families. Rahmawaty et al [15] found 34 medicinal plants in the agroforestry land in the buffer area of Gunung Leuser National Park. Giesen [16] identified 221 medicinal plants in Indonesia peat swamp forests. The quality of soil fertility in MADAPI Forest is quite good where the soil pH was not quite low (4.6 - 5.1). The small number of medicinal plants found is possibly due to the disruption of human activity in the area where the MADAPI Forest in recent years has been functioned as a tourist area. The number of open areas and land used for tourism purposes affects the number of medicinal plant availability.

The highest number species found was *Diplazium esculentum*, which belongs to Athyriaceae family. This species was found evenly in all four sections found in the A. *moluccana* area. This species easily spread and grows in various habitats, particularly in moist areas [17]. Jones et al [18]) reported that *D. esculentum* is an invasive terrestrial fern. This type is an edible fern that often used by people as vegetables [19]. As a medicinal plant, this species utilized to heal wounds and skin infections, dysentery, diarrhea, fever, antioxidants, and various other health benefits [20]. This species is a herb and grows in groups because of its propagation through spores and rhizomes (budding) which are mainly spread around the parent plant.

Table 2. The abundance of the plants at the study sites

No	Species	S. *mahogani* section		A.*dammara* section		P. *merkusii* section		A. *moluccana* section	
		∑ individu species	Abundance (%)	∑ individu species	Abundance (%)	∑ individu species	Abundance (%)	∑ individu species	Abundance (%)
1	*Ageratum conyzoides*	-		20	19.02	30	9.59	-	
2	*Aleurites moluccana*	-		-	0.00	-	0.00	58	62.00
3	*Alstonia scholaris*	1	0.001	-	0.00	-	0.00	-	0.00
4	*Alternanthera sessilis*	-		11	10.46	7	2.24	-	0.00
5	*Andrographis paniculata*	-		-	0.00	2	0.64	-	0.00
6	*Artocarpus altilis*	3	0.03	-	0.00	-	0.00	-	0.00
7	*Asplenium nidus*	-		-	0.00	3	0.96	-	0.00
8	*Bambusa multiplex*	4	0.15	-	0.00	18	0.23	1	0.02
9	*Ceiba pentandra*	-		-	0.00	3	0.01	-	0.00
10	*Centella asiatica*	-		-	0.00	64	20.46	-	0.00
11	*Chromolaena odorata*	-		20	19.02	-	0.00	-	0.00
12	*Clidemia hirta*	3	0.12	63	2.40	168	2.15	13	0.23
13	*Coffea sp.*	-		20	0.76	63	0.81	-	0.00
14	*Curculigo latifolia*	-		-	0.00	4	1.28	-	0.00
15	*Diplazium esculentum*	68	65.52	41	39.00	92	29.41	120	53.04
16	*Dracontomelon dao*	20	0.19	-	0.00	-	0.00	-	0
17	*Erechtites valerianifolius*	4	3.85	20	19.02	80	25.58	2	0.88
18	*Etlingera elatior*	-		-	0.00	-	0.00	98	43.32
19	*Eurycoma longifolia*	-		-	0.00	2	0.03	-	0.00
20	*Ficus benjamina*	-		1	0.01	-	0.00	-	0.00
21	*Ficus septica Burm*	-		-	0.00	4	0.01	-	0.00
22	*Flagellaria indica*	13	0.50	8	0.30	20	0.26	-	0.00
23	*Homalomena cordata*	5	4.82	4	3.80	10	3.20	-	0.00
24	*Imperata cylindrica*	24	23.12	4	3.80	4	1.28	-	0.00
25	*Lantana camara*	-		30	1.14	3	0.04	-	0.00
26	*Melastoma malabathricum*	-		-	0.00	19	0.24	-	0.00
27	*Piper betle*	1	0.04	4	0.15	14	0.18	2	0.04
28	*Psidium guajava*	-		-	0.00	-	0.00	1	0.00
29	*Pyrrosia piloselloides*	-		-	0.00	4	1.28	5	2.21
30	*Solanum torvum*	1	0.04	3	0.11	9	0.12	-	0.00
31	*Swietenia mahagoni*	167	61.00	-	0.00	-	0.00	-	0.00
32	*Syzygium malaccensis*	-		-	0.00	-	0.00	1	0.00
33	*Trema orientalis*	-		-	0.00	9	0.03	-	0

The second most common species was *Clidemia hirta* which belongs to the family Melastomaceae. Le et al. [21] mentioned that this species is an invasive alien species originating from South America and has colonized tropical forests in Southeast Asia. Their study resulted that *C. hirta* commonly found along roads and trail that have a strong light. This *C. hirta* is most numerous in the P. *merkusii* section which has more openings due to cone-shaped pine canopy. *C. hirta* found in a small number in the more shaded forest floor of S. *mahagoni* and A. *moluccana* sections due to their closed canopy cover. C. *hirta* is a shrub and used as a wound healer. Rizki et al [22] reported that this species was one of the traditional medicinal plants by the indigenous people of West Pasaman, Indonesia.

The third most found species found was *Chromolaena odorata* which belongs to the family Asteraceae. This species was found only in A. *dammara* section. This species originated from America but is now commonly found in sub-Saharan Africa, Asia, and Oceania. *C. odorata* is a perennial shrub that is quite invasive so that it is considered a serious weed. However, this species has lots of health benefits and is commonly used by people in ethnopharmacological uses such as treatment fotr stomachache, coughs, and colds, toothache, malaria,

diarrhea, skin infection [23]. Utami and Rahadian [14] reported that this species was one of the most prevalent medicinal plants found in Penggaron tourism forest of Central Java, Indonesia that benefit as anti-inflames and anti-diabetic. Rohman et al [24] reported that the Tengger tribe located in Bromo Tengger Semeru National Park, East Java utilized *C. odorata* as an insect repellent. Rahmawati et al [25] mentioned this species utilized by To Manui ethnic of Central Sulawesi, Indonesia as a flu healer.

All the medicinal plants identified were categorized as rare since the MADAPI Forest has functioned as a tourist area visited by lots of people. This condition leads to disrupt the growth, spread, and presence of plants including medicinal plants.

3.2 Spatial Distribution

Most of the medicinal species in MADAPI forest had VMR >1, indicating clumped distribution. A few species were distributed uniformly and randomly. The highest VMR was shown by *E. elatior*, followed by *D. esculentum, A. moluccana , B. multiplex, S. mahagoni , L. camara, C. hirta, I. cylindrica, Coffea sp*., and *A. conyzoides* (Table 3 and Figure 4).

Table 3. Spatial distribution the medicinal plant species at the study sites

Species	Varian	Mean	Varian/Mean (VMR	Distribution Pattern
A. conyzoides	27.540	5.120	5.379	Clumped
A. moluccana	130.500	11.600	11.250	Clumped
A. scholaris	0.253	0.500	0.506	Uniform
A. sessilis	8.880	3.000	2.960	Clumped
A. paniculata	10.601	3.250	3.262	Clumped
A. altilis	0.550	0.750	0.733	Uniform
A.nidus	1.000	1.000	1.000	Random
B. multiplex	84.400	9.000	9.378	Clumped
C. pentandra	0.550	0.750	0.733	Uniform
C. asiatica	24.300	5.300	4.585	Clumped
C. odorata	15.500	4.500	3.444	Clumped
C. hirta	66.143	7.484	8.838	Clumped
Coffea sp.	34.700	5.900	5.881	Clumped
C. latifolia	3.533	1.333	2.650	Clumped
D. esculentum	123.039	9.171	13.416	Clumped
D. dao	3.000	1.800	1.667	Clumped
E. valerianifolius	16.000	4.000	4.000	Clumped
E. elatior	372.000	19.600	18.980	Clumped
E. longifolia	0.440	0.600	0.733	Clumped
F. benjamina	0.200	0.500	0.400	Uniform
F. septica	0.980	1.000	0.980	Uniform
F. indica	3.300	1.900	1.737	Clumped
H. cordata	12.000	3.750	3.200	Clumped
I. cylindrica	41.960	6.400	6.556	Clumped
L. camara	73.487	8.250	8.908	Clumped
M. malabathricum	21.200	4.700	4.511	Clumped
P. betle	23.260	5.000	4.652	Clumped
P. guajava	0.253	0.500	0.506	Uniform
P. piloselloides	5.032	2.250	2.236	Clumped
S. torvum	3.300	2.700	1.222	Clumped
S. mahagoni	99.200	10.600	9.358	Clumped
S. malaccensis	0.253	0.500	0.506	Uniform
T. orientalis	8.900	3.000	2.967	Clumped

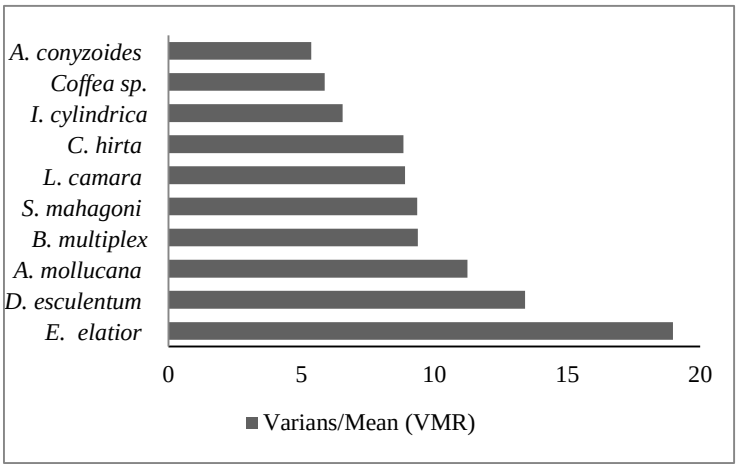

Figure 4. The top ten of the highest VMR of the medicinal plants

Plant distribution patterns generally consist of three distribution patterns namely random, uniform, and clumped. Generally, most plant species are clumped in an area. Genetic factors of the species may cause a different distribution pattern [26]. However, the distribution pattern is also affected by interactions between individuals in the ecosystem. The effect of environmental and competition factors may hamper the species to spread far away from the parent plant. Amaral et al [27] mentioned that the species which cannot survive under a specific environment leads to growth in a clump distribution pattern. Susilowati et al [28] reported that *Eurycoma longifolia* seedling was distributed in groups and close to the mother plants. Lestari and Asih [29] mentioned that seed spreading agents may affect the distribution of plants, so that clustered plants usually do not have agents to spread the seeds. According to Russo and Augspurger [30] some factors such as seed predators, seed spreading agents and seedling pathogens may affect plant distribution patterns. This is confirmed by Okuda et al [31] stated that the number of seeds, seedling predators, and low species mortality rates also cause clump distribution patterns for plants. Human disturbances may affect the effectiveness of plant distribution patterns. A safe location and far from human accessibility and disturbance lead to plants to grow in a clumped pattern.

4. CONCLUSION

There were 33 species of medicinal plants were found, representing 27 families. The most dominant families found in the sites were Asteraceae and Moraceae Mostly the plants were herbs. All of medicinal plant species were categorized as rare with clumped distribution; only a few species were spread randomly or uniformly.

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