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Short Communication

DISSIMILARITY OF SAVANNA PLANT COMMUNITIES ON MOUNT TAMBORA AND RINJANI IN WEST NUSA TENGGARA, INDONESIA

Perbedaan Komunitas Tumbuhan Sabana pada Gunung Tambora dan Rinjani di Nusa Tenggara Barat, Indonesia

Sutomo*, Rajif Iryadi, I Dewa Putu Darma, I Putu Agus Hendra Wibawa

Research Center for Plant Conservation, Botanic Gardens, and Forestry - National Research and Innovation Agency (BRIN)
Jl. Ir. H. Juanda No.13 Kota Bogor, Jawa Barat, Indonesia 16003

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***Koresponden E-mail** :
tommo.murdoch@gmail.com

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Kontributor

Kontributor Utama/*Main author*:
Sutomo
Rajif Iryadi
I Dewa Putu Darma
I Putu Agus Hendra Wibawa

Kontributor Anggota/*Author member*:
-

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Abstrak

Sabana ternyata juga terdapat di dataran tinggi, seperti sabana yang terbentuk di lereng Gunung Rinjani dan Gunung Tambora. Informasi tentang kedua sabana tersebut belum banyak diketahui dibandingkan dengan sabana lain di Indonesia. Penelitian ini bertujuan untuk mengkaji dan membandingkan karakteristik dan variasi komposisi komunitas tumbuhan sabana di dataran tinggi G. Rinjani dan G. Tambora. Metode pengambilan sampel dilakukan secara *purposive* (dengan awal acak) di sepanjang sabana untuk mendapatkan informasi kelimpahan jenis tumbuhan berkayu dan juga kelimpahan jenis penutup tanah. Data vegetasi dianalisis dengan Analisis Kesamaan (ANOSIM), CLUSTER dan SIMPER dengan menggunakan perangkat lunak PRIMER V.6. Tercatat ada 45 spesies tumbuhan yang termasuk dalam 27 famili di dua sabana tersebut. Kedua sabana memiliki keanekaragaman spesies yang hampir sama (1,72 untuk G. Tambora dan 1,85 untuk G. Rinjani). *Saccharum spontaneum*, *Desmodium* sp., *Ziziphus rotundifolia*, *Acacia nilotica*, dan *Tabernaemontana* sp. hanya terdapat di G. Tambora, sedangkan *Dicranopteris linearis*, *Stachytarpeta indica*, *Engelhardia spicata*, *Ocimum* sp., *Vanda* sp., *Rubus* sp., dan *Nephrolephis* sp. hanya ditemukan di G. Rinjani. *Imperata cylindrica* banyak ditemukan dan berpotensi memicu kebakaran liar di kedua sabana tersebut. Invasi spesies asing invasif, seperti *Acacia nilotica* mulai terjadi di G. Tambora.

Abstract

Some savannas occur at high elevations in Indonesia, such as those found on the slopes of Mt. Rinjani and Mt. Tambora. Such savannas are poorly known compared to other savannas in Indonesia. This study investigates and compares the structural characteristics and species composition of savanna plant communities in the higher altitude areas of Mt. Rinjani and Mt. Tambora. Sampling was established purposively (with a random start) across each savanna to get the abundance of woody and groundcover species. The floristic data were analyzed using Analysis of Similarity (ANOSIM), CLUSTER, and SIMPER, which feature in PRIMER v.6 software. We recorded 45 plants species belonging to 27 families in the two savannas. Both savannas have similar species diversity (1.72 for Mt. Tambora and 1.85 for Mt. Rinjani). *Saccharum spontaneum*, *Desmodium* sp., *Ziziphus rotundifolia*, *Acacia nilotica*, *Tabernaemontana* sp. were the species only present on Mt Tambora; whereas *Dicranopteris linearis*, *Stachytarpeta indica, Engelhardia spicata, Ocimum* sp., *Vanda* sp., *Rubus* sp., and *Nephrolepis* sp. were the species only found on Mt. Rinjani. *Imperata cylindrica* is commonly found in both savannas and can increase wildfire risk in these savannas. The spread of the invasive alien species, *Acacia nilotica*, has started on Mt. Tambora.

INTRODUCTION

Savannas are ecosystems typically characterized by a continuous cover of C4 grasses. Where woody plants are also an important feature, but with meager cover and no closed canopy (Frost *et al.* 1986) and are common in lowland settings across Indonesia. Savannas also occur at higher elevations, such as the savanna formations on Mt. Rinjani of Lombok Island and Mt. Tambora in Sumbawa Island, West Nusa Tenggara. In Cornelis van Steenis's botanical surveys of Java Island, such vegetation would be classified as high elevation grassland (van Steenis 1972). Most highland savannas occur on a slope of volcanic mountain across Java, Bali, Lombok and Sumbawa, such as Mt. Galunggung, Mt. Sumbing, Mt. Merapi-Merbabu, Mt. Lawu, Mt. Semeru, Mt. Batur, Mt. Rinjani and Mt. Tambora (Sutomo & van Etten 2018). Fire, most probably started by volcanic activity according to van Steenis (1972), is likely to be the significant factor maintaining these grasslands on Java mountains, especially in East Java which is subject to a more pronounced dry season (less rain and extended period of the dry season) and lower annual precipitation compared to other parts of the Island. Fires in the tropics are generally believed to create and maintain savanna (or a more open woody vegetation with grassy understory) in regions that should be forest-based on rainfall alone (Bond *et al.* 2005), such as much of Indonesia. This may also be true for the savannas on Lombok and Sumbawa Islands, West Nusa Tenggara.

Tropical savanna communities in West Nusa Tenggara is little known, unlike those in East Nusa Tenggara (Monk *et al.* 2000; Fisher *et al.* 2006; Russel-Smith *et al.* 2006; Martono 2012). The description of savannas across the Indonesian Archipelago is scarce. The distribution of savannas in Nusa Tenggara and Maluku (NTM) can be seen in Table 1, as extracted from Monk *et al.* (2000). However, some descriptions of the savannas in NTM are generally inadequate compared to the area covered by NTM savannas (Monk *et al.* 2000).

Table 1. Distribution of savannas in Nusa Tenggara and Maluku

Island	% of island
Lombok	1.15
Sumbawa	5.60
Komodo, Flores, Lomblen, and Alor	4.99
Sumba	22.77
West Timor and Rote	13.30
East Timor	16.15
Banda Islands	9.72

Specifically, this study investigates characteristics and variations in the composition of savanna plant communities in the higher altitude parts of Mt. Rinjani and Mt. Tambora to fill the gap in the literature regarding savannas in Indonesia in general.

MATERIALS AND METHODS

The study was conducted on Mt. Rinjani, Lombok West Nusa Tenggara Indonesia, at an altitude of 1,120 m above sea level (asl) and Mt Tambora at 774 m asl. On Mt. Tambora, savanna was sampled at 87 m asl. minimum and 774 m asl. maximum, whereas on Mt. Rinjani, it was 1,085 m asl. minimum elevation and at 1,120 m asl. top. Seven sampling plots (20 x 20 m) for Rinjani and six plots on Tambora were established purposively (with a random start) across the savannas (Figure 1). We recorded the abundance of woody species (trees and shrubs) in the 20 x 20 m plot and herbaceous ground cover species (using 2 x 2 m plot) nested in each bigger plot. Each plot's geographical position and elevation were marked with handheld GPS GARMIN GPS 76CSX. In each plot, we also estimated the cover of each species. Plant species identification was either completed in the field or, if not known, identified using plant specimens in the collection at the *Herbarium Baliensis* within the Bali Botanic Garden (BRIN). This botanical garden has an abundance of specimens collected from eastern parts of Indonesia, which is its specialty. A resemblance matrix was formed comparing each plot using the Bray-Curtis similarity index (Valessini 2009).

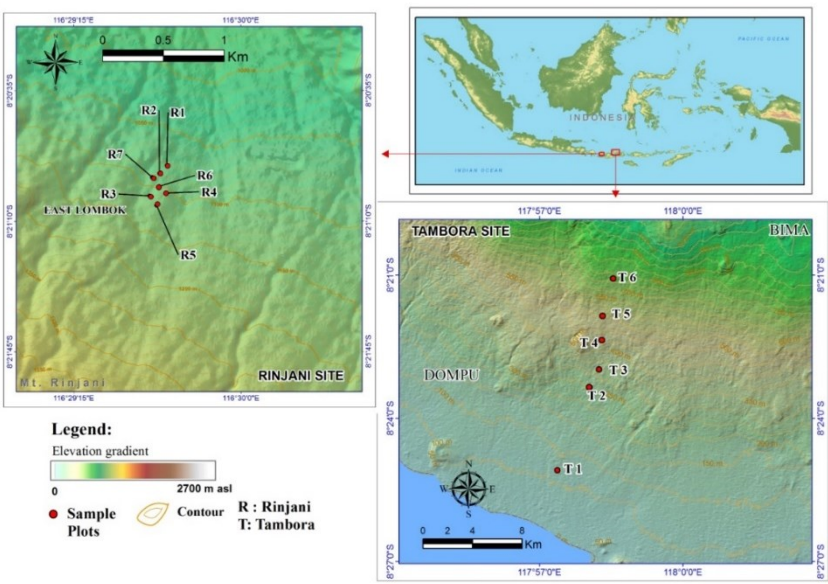

Figure 1. The sample plots of Mt. Tambora and Mt. Rinjani area

Analysis of Similarity (ANOSIM) was used to detect any differences in floristic and environmental factors between the savannas (Clarke *et al.* 2008). This analysis gives a RANOSIM value ranging from 0 (no different) to 1 (very different). Cluster analysis was then conducted using the resemblance matrix. SIMPER (Similarity Percentage) analysis was then used to explore the relative contribution of individual species to dissimilarity among savannas. This multivariate analysis used the PRIMER v.6 packages (Clarke & Gorley 2005). The Shannon diversity index was also calculated for the Tambora and Rinjani sites with the following formula (Magurran 2004):

$$H' = -\sum_{i=1}^{S} Pi \ln Pi$$

Where:
H' = Shannon diversity index
S = Number of species in community
Pi = Proportion of total abundance represented by i-th species

RESULTS AND DISCUSSION

A total of 23 species belonging to 27 families were recorded in the two savannas (Figure 2). Most species were from Leguminosae (Fabaceae), followed by Euphorbiaceae, and Poaceae (Figure 2). Specific species that characterize the Mt. Tambora savanna were *Digitaria ciliaris*, *Chromolaena odorata* (shrub, invasive exotic), and *Imperata cylindrica* (cogon grass) (Table 2). The important species of the Mt Rinjani savanna were *Stachytarpeta indica, D. linearis, Lantana camara, I. cylindrica,* and *C. odorata* (shrub and invasive exotic) (Table 3). Mt. Tambora and Mt. Rinjani savanna have many common species as those of other Southeast Asia, especially in Thailand, where species such as *I. cylindrica*, *L. camara*, and *C. odorata* are common (Kurz 1876; Kodandapani 2013; Ratnam *et al.* 2016).

Both savannas have almost similar species diversity (1.72 for Mt. Tambora and 1.85 for Mt. Rinjani using the Shannon diversity index). Generally, tropical savannas have high local-scale plant species diversity, for example, the Brazillian cerrado (Furley 1999) compared with temperate grasslands (Solbrig *et al.* 1996). However, several factors, such as the invasion of exotic species, could reduce this diversity. In this study, the savannas diversity is low to moderate (Magurran 1988, 2004). Moderate species diversity is also found in other Asian savannas, such as India (Pandey & Singh 1991). According to Sutomo & van Etten (2021), the savanna on Mt. Rinjani has the highest species diversity compared to the other savannas in Indonesia, such as in Baluran National Park (NP), Alas Purwo NP, and Bali Barat NP.

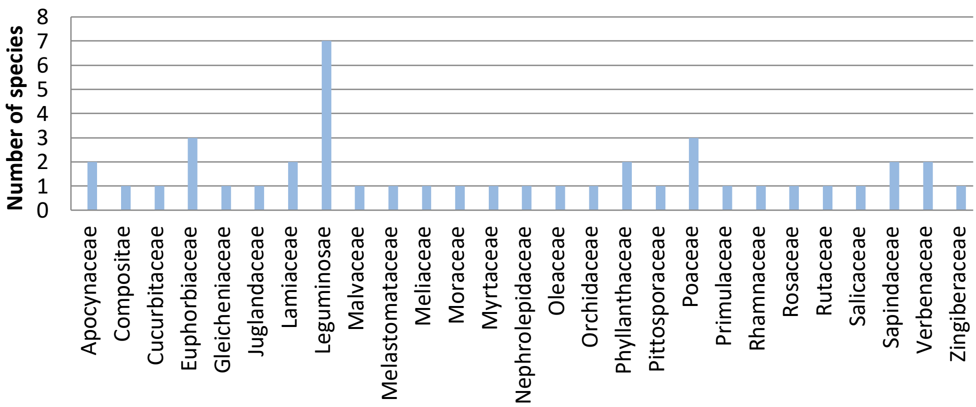

Figure 2. Common plant families found based on number of species recorded across both savannas

Table 2. SIMPER analysis result for savanna plant community on Mt. Tambora

Species	Av. Abund	Contrib (%)
Digitaria ciliaris (Retz.) Koeler	4.18	21.20
Chromolaena odorata (L.) R.M.King & H.Rob.	3.03	19.98
Imperata cylindrica (L.) P.Beauv.	3.89	18.38

Table 3. SIMPER analysis result for savanna plant community on Mt. Rinjani

Species	Av. Abund	Contrib (%)
Imperata cylindrica (L.) P.Beauv.	4.24	21.40
Stachytarpheta indica (L.) Vahl	4.31	18.93
Chromolaena odorata (L.) R.M.King & H.Rob.	4.62	17.86
Dicranopteris linearis (Burm.f.) Underw.	4.83	14.21
Lantana camara L.	3.49	11.97

ANOSIM test revealed that there is a significant difference (R = 0.58; $p < 0.001$) in the community composition of the two savannas (Figure 3). The cluster analysis (Figure 4) showed that the plots were grouped into two main clusters based on savanna location. The similarity between the two main groups was only approximately 30%. These results were also confirmed by the results from SIMPER analysis (Table 4) which shows that the average dissimilarity between the two groups is 74.53%.

Saccharum spontaneum, *Desmodium* sp., *Ziziphus rotundifolia*, *Acacia nilotica*, *Tabernaemontana* sp. were the species present only on Mt Tambora. Whereas *Dicranopteris linearis, Stachytarpeta indica, Engelhardia spicata*, *Ocimum* sp., *Vanda* sp., *Rubus* sp., and *Nephrolepis* sp. were only found on Mt. Rinjani. *I. cylindrica* (cogon grass) occurred widely in both savannas. One of the main factors promoting the occurrence of cogon grass is sporadic wildfires, which are known to occur on these two mountains. *I. cylindrica* is also a potential problem on the Mt. Merapi volcano of Central Java as it has become so dominant that it represents a major fire hazard that can be easily ignited, either from extreme temperature, lightning, or by a fire sparked by the falling of rocks from the upper slope of the volcano (Andrews 1983). It is also adapted to fire as the fire stimulates flowering (MacDonald 2009). Thus *I. cylindrica* dominance could increase fire frequency and reduce biodiversity (Soerjani *et al*. 1983; Murniati 2002).

Several species presented in Table 4 highlights the floristic differences between the two savannas, are invasive species (exotic). At Mt. Tambora, one species of concern is an exotic invasive species, *Acacia nilotica*. This finding requires serious attention from the park managers as *A. nilotica* has the high potential to be very problematic in the future. The case of invasion of *A. nilotica* in the Baluran Savanna in north-eastern Java is a prime example of the threat posed by this species (Sutomo 2014). In this important national park, invasion by *A. nilotica* has effectively reduced the size of the Bekol Savanna. Sutomo *et al.* (2016) noted that, over fourteen years, the area of savanna has decreased from approximately 6,510 ha in 2000 to 5,149 ha in 2014.

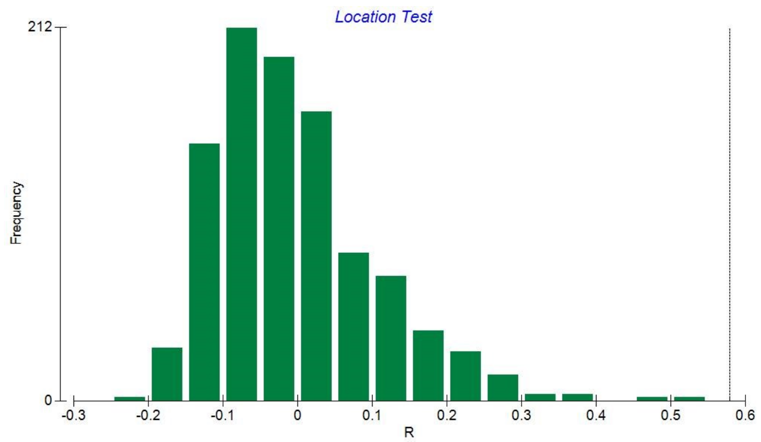

Figure 3. The community composition of Mt. Tambora and MT. Rinjani savannas generated by ANOSIM test. Sample statistic (Global R): 0.579. The significance level of sample statistic: 0.1%. The number of permutations: 999

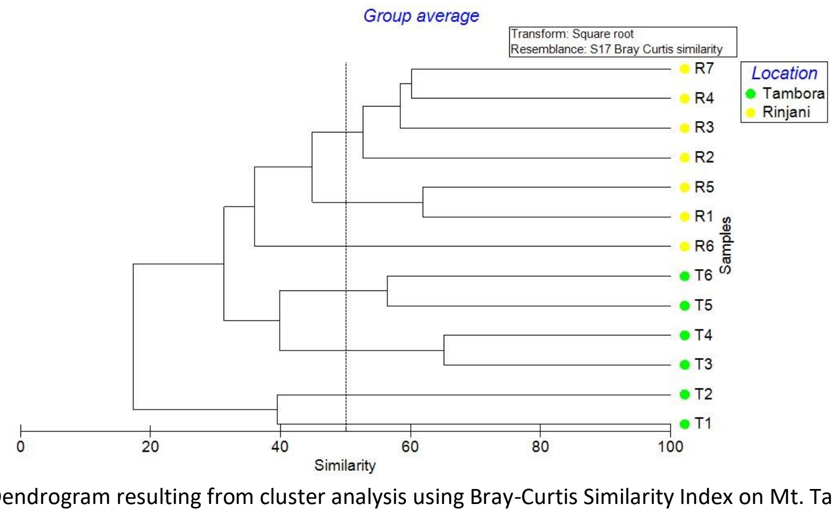

Figure 4. Dendrogram resulting from cluster analysis using Bray-Curtis Similarity Index on Mt. Tambora and Mt. Rinjani savannas. The slicing dashed line shows 50% similarity.

Table 4. The average dissimilarity between the Groups of Mt. Tambora and Mt. Rinjani generated by SIMPER analysis.

Species	Group Tambora Av. Abund	Group Rinjani Av. Abund	Av. Diss	Diss/SD	Contrib (%)
Dicranopteris linearis (Burm.f.) Underw.	0.00	4.83	7.24	1.33	9.71
Stachytarpheta indica (L.) Vahl	0.00	4.31	6.79	1.99	9.11
Digitaria ciliaris (Retz.) Koeler	4.18	1.92	5.53	1.34	7.42
Lantana camara L.	0.73	3.49	4.68	1.30	6.28
Chromolaena odorata (L.) R.M.King & H.Rob.	3.03	4.62	4.52	1.44	6.06
Imperata cylindrica (L.) P.Beauv.	3.89	4.24	4.42	1.30	5.93
Saccharum spontaneum L.	1.76	0.00	3.08	0.58	4.13
Sida rhombifolia L.	1.78	0.39	2.45	1.26	3.29
Desmodium sp.	1.58	0.00	2.30	0.94	3.08
Melastoma sp.	0.71	1.29	2.00	1.20	2.69
Ziziphus nummularia (Burm.f.) Wight & Arn.	1.10	0.00	1.89	0.89	2.53
Engelhardia spicata Lechen ex Blume	0.00	1.17	1.83	0.97	2.46
Jatropha sp.	0.29	0.85	1.69	0.55	2.26
Dodonaea sp.	0.37	0.71	1.48	0.59	1.98
Acacia nilotica (L.) Willd. ex Delile	0.84	0.00	1.43	0.88	1.92
Ocimum sp.	0.00	0.87	1.22	0.61	1.64
Tabernaemontana sp.	0.69	0.00	1.08	0.89	1.45
Psidium guajava L.	0.62	0.40	1.07	1.06	1.44
Ficus elastica Roxb. ex Hornem.	0.71	0.14	1.02	0.83	1.36
Vanda sp.	0.00	0.55	0.96	0.40	1.29
Macaranga tanarius (L.) Müll.Arg.	0.66	0.14	0.94	0.80	1.25
Rubus sp.	0.00	0.53	0.81	0.77	1.09
Nephrolepis sp.	0.00	0.59	0.81	0.40	1.00

CONCLUSION

Mt. Rinjani and Mt. Tambora are both volcanic areas where savanna ecosystems occur. Both savannas areas have almost similar species diversity (1.72 for Mt. Tambora and 1.85 for Mt. Rinjani), and the diversity is categorized into the low to moderate range for savanna. However, the dissimilarity in species composition between the two savannas is relatively high (74.53%), meaning they have few species in common. This information, along with the knowledge of invasive exotic species in the system, could be used as the basis for improving management in the two savannas.

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