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Scientific Article

POPULATION SIZE OF TWO ENDANGERED VIREYA RHODODENDRON SPECIES AND THEIR SURROUNDING VEGETATION ON THE TOP OF THE MT. RANTEMARIO, SULAWESI

Ukuran Populasi Dua Jenis Vireya Rhododendron Berkategori Genting dan Vegetasi Sekitarnya di Puncak Gunung Rantemario, Sulawesi

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Abstrak

Lima dari 29 jenis *Rhododendron* di Sulawesi terancam kepunahan dan dua diantaranya termasuk dalam kategori Genting (EN D). Pengamatan di lapangan telah dilakukan untuk menentukan ukuran populasi terkini dari *R. eymae* dan *R. nanophyton* var. *nanophyton* yang berkategori Genting tersebut. Seratus empat puluh plot (masing-masing berukuran 5x5 m^2) dibuat pada tujuh transek di kawasan puncak G. Rantemario (3,269–3,445 m dpl), Sulawesi Selatan. Hasil pengukuran berhasil menemukan 318 individu *R. eymae* dan dua individu *R. nanophyton* var. *nanophyton* dalam plot yang dibuat. Berdasarkan data yang diperoleh, ukuran populasi hasil estimasi dari dua jenis *Rhododendron* tersebut tidak memenuhi kriteria Genting (EN D). Kategori yang lebih tepat untuk dua jenis tersebut yaitu Rawan (VU D2). Pertimbangan perubahan kategori tersebut dijelaskan dalam makalah ini. Semak dan herba yang dominan di puncak G. Rantemario yaitu *Leptospermum javanica* (IVI=37.08), *Eriocaulon truncatum* (IVI=34.83), dan *Styphelia suaveolens* (IVI=24.63). Asosiasi ketiga jenis tumbuhan tersebut dengan dua jenis *Rhododendron* telah dianalisis.

Kata kunci: Genting, *Rhododendron*, Sulawesi, tropikal alpin, vegetasi

Abstract

Five of the 29 species of *Rhododendron* of Sulawesi are threatened and two of which have endangered category (EN D). Field assessment had been conducted to measure the current population size of the endangered *R. eymae* and *R. nanophyton* var. *nanophyton*. One hundred and fortyplots (of each 5x5 m^2) along seven transects were established around the summit of Mt. Rantemario (3,269–3,445 m asl.), South Sulawesi. The results showed that there were 318 individuals of *R. eymae* and two individuals of *R. nanophyton* var. *nanophyton* within the plots. We also found that the estimated population sizes of those two species have not met the criteria previously stated (EN D). The appropriated status for both species is Vulnerable (VU D2). The reasons for proposing this new category are discussed. The dominated shrubs and herbs on the summit area of

Mt. Rantemario were *Leptospermum javanica* (IVI=37.08), *Eriocaulon truncatum* (IVI=34.83), and *Styphelia suaveolens* (IVI=24.63). The association of those three plants with the *Rhododendron*'s were analysed.

Keywords: Endangered, *Rhododendron*, Sulawesi, tropical alpine, vegetation

INTRODUCTION

Sulawesi is the largest island of Wallacea region in Indonesia. The element of Sulawesi flora was associated between Sundaland on the west, Phillipines on the north, and Australasia components on the east. Therefore, Sulawesi flora were more heterogenous than other islands in Indonesia but higher in endemicity (Widjaja *et al.,* 2011). The endemicity of Sulawesi flora is relatively similar to Sumatera (12.3%) but is lower than Borneo (28.4%) and Papua (46.6%) (Roos *et al.,* 2004). The flora of Sulawesi remains poorly known (Kessler, 2002) and the collection rates of plant material amongst areas were not equivalent in Sulawesi (Cannon *et al*., 2007).

One of the poorly studied areas in the highlands of Sulawesi is Mount Rantemario (Figure 1). This mountain is the highest in Sulawesi (3,478 m asl.). It is one of the peak on Latimojong highland area of 580 km^2 and is located in three different subdistrict authorities of South Sulawesi Province. This area is a protected forest managed by the local goverment and designated since 1940. Based on the World Database on Protected Areas (IUCN & UNEP-WCMC, 2014), Latimojong highland has been categorized as a protected area implementing sustainable use of natural resources (category VI). This category possesses several objectives besides the protection of the natural resources. One of those objectives is ensuring sustainable livelihood of the local communities in the context of inter-generations. However, anthropogenic **disturbances** seem to continue in this area through logging, the establishment of pine forest, coffee plantation, and small-agricultural plots in a massive scale (Thomas *et al*., 2009). Those activities are unsustainable practical for the natural resources in the future.

Cannon *et al.* (2005) classified the forests above 2,200 m elevation of Sulawesi as Tropalpine (Tropical alpine). This type mostly still shows good condition but is vulnerable to disturbances and is slow to recover. The total extent of this forest type was only about one percent of the total Sulawesi land area and it was scattered across the island on small pathces (Cannon *et al.,* 2005). The woody plant species diversity is often quite low but herbaceous plants are often most diverse and unique in such forest type (Cannon *et al.*, 2005). One of plant groups that can be found at this habitat type is *Rhododendron* (Ericaceae) (Argent, 2006).

About 1,157 species of *Rhododendrons* have been assessed through IUCN Red List criteria and 316 among them were categorized as threatened species (Gibbs *et al.*, 2011). In Sulawesi, there were 29 species of *Rhododendron* (Argent, 2007). Five of which are threatened and four of these five threatened species were endemic to Mt. Rantemario (Argent, 2006). Two threatened species of the Sulawesi Rhododendrons have been listed as "Endangered" species and are endemic to the area of Mt. Rantemario, *i.e. Rhododendron eymae* Sleumer and *R. nanophyton* var. *nanophyton* Sleumer (Argent, 2006; Gibbs *et al.*, 2011. The assessment of those species was predominantly based on indirect evidences, *i.e.* from herbarium specimen, taxonomic publication, and expert opinion. These techniques result in a hard work especially to re-assess the species in the future (Brummit & Bachman*,* 2010).

Brummit *et al.* (2015) suggested a field-based assessment for species which were previously categorized by indirect assessments to increase the convidence level of the data. This data are needed to evaluate the Sample Red List Index (SRLI). The aims of the index are to measure projected extinction risk of species and to track changes of this risk (Butchart *et al*., 2007).

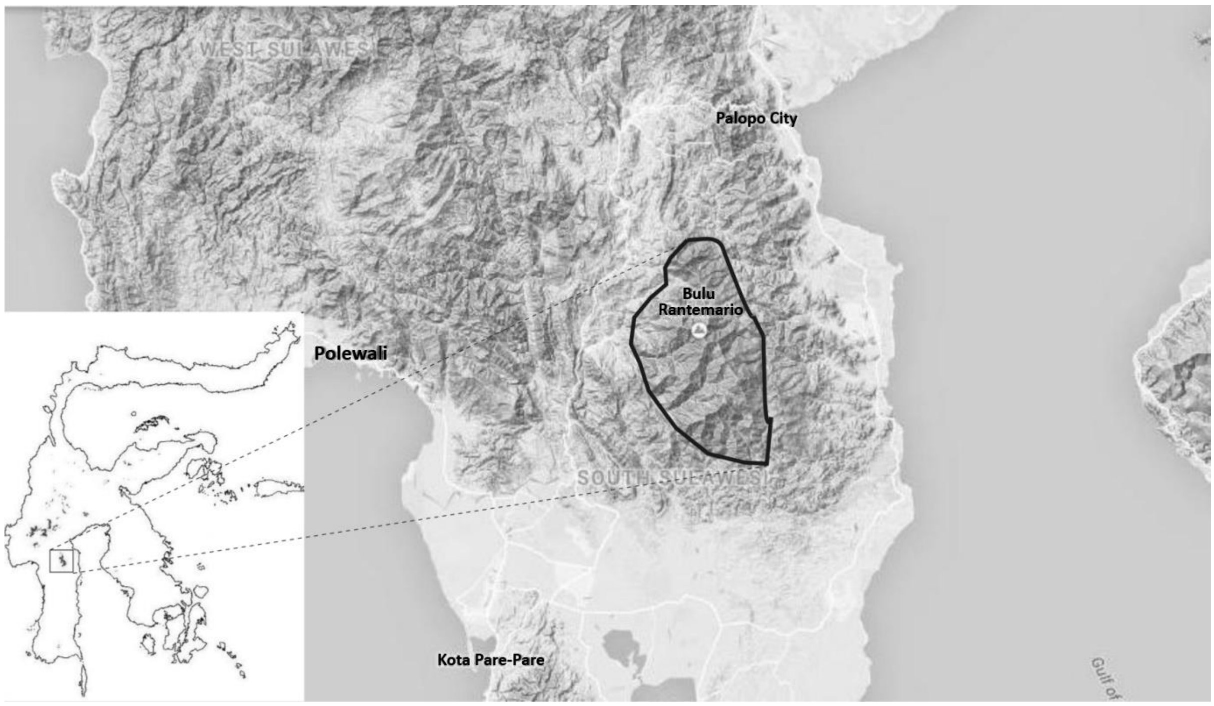

Figure 1. Location of Mt. Rantemario, South Sulawesi

The current status of *Rhododendron eymae* and *R. nanophyton* var. *nanophyton* showed that the species had only very small or restricted populations in which the numbers of mature individuals were less than 250 (Gibbs *et al.*, 2011). On the other hand, there was no clear information about the population sizes of those two *Rhododendron* species. This paper were aims to re-asses the current population size of *R. eymae* and *R. nanophyton* var. *nanophyton* and to describe the summit vegetation of Mt. Rantemario. This information will be useful to monitor the population size of those two species in the future.

MATERIALS AND METHODS

Population sizes of *Rhododendron eymae* and *R. nanophyton* var. *nanophyton* were measured based on the seven of each 50 m long transects with 10 m width on the summit area of Mt. Rantemario, South Sulawesi, Indonesia (Table 1). Gillison (2006) stated that a 40x5m^2 (200m^2) transect is adequate for vegetation survey and larger plot size is used in complex vegetation such in rough terrain sites. In general, there were two types of vegetation on the summit of Mt. Rantemario, *i.e.* rocky vegetation where no trees occurred and dense green area where trees (mostly at sapling size) occurred. We decided to establish randomly four transects in rocky sites and three transects in dense green area since the element compositions seem to be homogenous.

Within each transect, there were 20 of 5x5 m^2 plots where those two *Rhododendron* species were counted. Half of the plots on each transects were also used on vegetation analysis and three of 1x1 m^2 of subplot were established to be nested to those plots to measure herbs and seedling diversity. In total, there were 140 (5x5m^2) plots to measure population of the Rhododendrons and 70 (5x5 m^2) plots which contains 210 (1x1 m^2) plots.

The numbers of individuals of each species within the plots and subplots were counted to describe the population status within the area. When the plants cover more than one subplots, we counted each parts as its occured on those plots. Data were analyzed to measure the indices of density, frequency, and importance values. The herbarium specimens were collected and identified at the Cibodas Botanic Gardens'Herbarium (CHTJ) and the Herbarium Bogoriense (BO).

Interspesific plant association between herbs/seedling species and *R. eymae* and *R. nanophyton* var. *nanophyton* was calculated using the 2x2 contingency table of the species presence/absence data and analysed by the Chi-square (χ^2) test. The significance of χ^2 test is determined by comparing the χ^2 observed and χ^2 theoretical distribution at p=0.05; df=1. Type of association is positive (+) if the χ^2 observed > the χ^2 theoretical and the observed co-occurence of both species is higher than the expected or negative (-) if the χ^2 observed > the χ^2 theoretical and the observed co-occurence of both species is lower than the expected. Positive association means that the pair of species is occurred together more often. While, negative association means that the pair of species is occurred together less often. The strength level of association was measured by Ochiai Index.

RESULTS AND DISCUSSION

Population of *R. eymae* and *R. nanophyton*

There were 318 individuals of *R. eymae* from seven transects or equals 909 individuals/ha. There were only four individuals of *R. nanophyton* var. *nanophyton* or equals 11 individuals/ha. Total numbers of individual plants of those two species were also extrapolated to the total area of above 3,100 m around the summit of Mt. Rantemario as Argent (2006) and Sleumer (1966) mentioned that those plants can only be found at this altitude. Based on the measurement using *Google Earth*™, the area above 3,100 m around the summit of Mt. Rantemario is 6 km^2. The population size of *R. eymae* and *R. nanophyton* var. *nanophyton* was estimated (Table 1).

The Vegetation at Top of Mt. Rantemario

Within 210 subplots (of each 1x1 m^2), 2,550 individual plants belonging to 33 species of shrubs and herbs were recorded (Table2). The top five plant species dominated the vegetation on the summit of Mt. Rantemario were *Leptospermum javanica* (IVI = 37.078), *Eriocaulon truncatum*. (IVI = 34.832), *Styphelia suaveolens*. (IVI= 24.626), *Rytidosperma oreoboloides*(IVI = 14.921), and *Gentiana* sp1. (IVI = 13.778). *R. eymae* (IVI = 5.388) was only found within 30 subplots consisting 56 individuals. *R. nanophyton* (IVI = 0.185) was only found on one subplot (2 individuals). There were only three tree species that occurs on the plots. The highest basal area (9.67 m^2/ha) was *Leptospermum javanica* (Table 3).

Based on the association test, *R. eymae* was associated with *L. javanica*, *Gentiana* sp1., and *G. celebica* (Table 4). The association type was positive for *L. javanica* and *Gentiana* sp. and negative for *G. celebica*. It means that *R. eymae* had high probability to occur together with *L. javanica* (especially at the seedling stage) and *Gentiana* sp1. In contrast, *R. eymae* was unlikely to co-occur with *G. celebica*. While, *R. nanophyton* var. *nanophyton* was only associated with *Vaccinium* sp. and the association type was positive.

Overall, the results show that the estimated population sizes of *R. eymae* and *R. nanophyton* var. *nanophyton* were 545,400 and 6,600 individuals, respectively. It means that the population sizes of those two species were not met the category and criteria of EN D the of IUCN Red List threathened species (IUCN, 2012).

The evidences above show that the red list assessments predominantly conducted based on the herbarium and publication information are not concomitant with the real situation in the field. It is a good sample of what Brummitt *et al.* (2015) has suggested. Re-assessing plant conservation status will provide us a vigorous data for future monitoring and elevate the confidence of the estimated population.

Table 1. Numbers of Individuals of *Rhododendron eymae* and *Rhododendron nanophyton* around the Summit of Mt. Rantemario, South Sulawesi.

No	Location	Elevation (m asl.)	Longitude	Latitude	Number of Individuals	
					R. eymae	*R. nanophyton* var. *Nanophyton*
1	Transect-1	3,445	120° 01.454’	03° 23.106’	0	0
2	Transect-2	3,440	120° 01.454’	03° 23.106’	30	0
3	Transect-3	3,413	120° 01.459’	03° 23.131’	63	0
4	Transect-4	3,269	120° 01.784’	03° 23.655’	133	0
5	Transect-5	3,277	120° 01.767’	03° 23.658’	92	0
6	Transect-6	3,283	120° 01.733’	03° 23.675’	0	0
7	Transect-7	3,292	120° 01.730’	03° 23.679’	0	4
Total					318	4
Estimated (ha^{-1})					909	11
Estimated area above 3,100 m around the Summit of Mt. Rantemario = 6 km^2					545,400	6,600

Table 2. Important Value Index (IVI) of Shrubs and Herbs on the Summit of Mt. Rantemario.

No	Species	No. of Individuals	Density	Relative Density	Frequency	Relative Frequency	IVI
1	*Leptospermum javanica*	506	2.410	19.843	0.771	17.235	37.078
2	*Eriocaulon truncatum*	465	2.214	18.235	0.743	16.596	34.832
3	*Styphelia suaveolens*	297	1.414	11.647	0.581	12.979	24.626
4	*Rytidosperma oreoboloides*	196	0.933	7.686	0.324	7.234	14.921
5	*Gentiana* sp1.	175	0.833	6.863	0.310	6.915	13.778
6	*Vaccinium* sp.	159	0.757	6.235	0.195	4.362	10.597
7	*Gleichenia vulcanica*	132	0.629	5.176	0.176	3.936	9.113
8	*Lindernia* sp.	90	0.429	3.529	0.152	3.404	6.934
9	*Gaultheria celebica*	84	0.400	3.294	0.162	3.617	6.911
10	*Lycopodium campanulatum*	95	0.452	3.725	0.138	3.085	6.811
11	*Rhododendron eymae*	56	0.267	2.196	0.143	3.192	5.388
12	*Poa papuana*	41	0.195	1.608	0.110	2.447	4.055
13	Rubiaceae 1	34	0.162	1.333	0.114	2.553	3.887
14	*Polystichum aculeatum*	36	0.171	1.412	0.081	1.809	3.220
15	*Selaginella* sp1.	27	0.129	1.059	0.057	1.277	2.335
16	*Keysseria trachyphilla*	16	0.076	0.627	0.052	1.170	1.798
17	*Gaultheria viridiflora*	20	0.095	0.784	0.038	0.851	1.635
18	*Potentilla papuana*	20	0.095	0.784	0.038	0.851	1.635
19	*Rapanea* sp.	13	0.062	0.510	0.048	1.064	1.574
20	*Swertia* sp.	13	0.062	0.510	0.038	0.851	1.361
21	*Pittosporum* sp.	9	0.043	0.353	0.043	0.957	1.310
22	*Rhododendron lagunculicarpum*	8	0.038	0.314	0.029	0.638	0.952
23	*Microlepia manilensis*	5	0.024	0.196	0.019	0.426	0.622
24	*Elaphoglossum callifolium*	7	0.033	0.275	0.014	0.319	0.594
25	*Rubus* sp.	6	0.029	0.235	0.010	0.213	0.448
26	Poaceae-3	5	0.024	0.196	0.010	0.213	0.409
27	Asteraceae-2	3	0.014	0.118	0.010	0.213	0.330
28	*Lycopodium* sp.	3	0.014	0.118	0.010	0.213	0.330
29	Asteraceae-3	4	0.019	0.157	0.005	0.106	0.263
30	*Selaginella* sp2.	4	0.019	0.157	0.005	0.106	0.263
31	*Gentiana* sp2.	2	0.010	0.078	0.005	0.106	0.185
32	*Rhododendron nanophyton*	2	0.010	0.078	0.005	0.106	0.185
33	*Rhododendron pseudobuxifolium*	1	0.005	0.039	0.005	0.106	0.146

Table 3. Tree Species Occurred on the Summit of Mt. Rantemario

No	Species	Family	No. of Individuals	Total Basal Area (m^2)	Estimated Basal Area (m^2/ha)
1	*Leptospermum javanica*	Myrtaceae	171	0.72	9.67
2	Rubiaceae 1	Rubiaceae	2	0.01	0.15
3	*Rhododendron lagunculicarpum*	Ericaceae	1	0.003	0.04

Table 4. Chi-square (χ^2) test of Association, Type of Association, and Association Index (Ochiai Index) of *Rhododendron eymae, Rhododendron nanophyton* var. *nanophyton* and Ten Dominated Plant Species around The Summit of Mt. Rantemario, South Sulawesi.

Paired Species	χ_t^2	Result of Chi-squared	Type of Association	Ochiai Index
*R. eymae*vs				
Leptospermum javanica	8.934	Associated	**Positive**	0.407
Eriocaulon truncatum	3.277	Not Associated	Not Associated	0.368
Styphelia suaveolens	1.138	Not Associated	Not Associated	0.227
Rytidosperma oreoboloides	0.025	Not Associated	Not Associated	0.191
Gentiana sp1.	19.834	Associated	**Positive**	0.436
Vaccinium sp.	2.225	Not Associated	Not Associated	0.063
Gleichenia vulcanica	0.793	Not Associated	Not Associated	0.096
Gaultheria celebica	5.985	Associated	**Negative**	0
Lycopodium campanulatum	2.317	Not Associated	Not Associated	0.037
Poa papuana	0.474	Not Associated	Not Associated	0.161
R. nanophyton var. *nanophyton*vs				
Leptospermum javanica	0.289	Not Associated	Not Associated	0.078
Eriocaulon truncatum	0.343	Not Associated	Not Associated	0.08
Styphelia suaveolens	0.739	Not Associated	Not Associated	0.091
Rytidosperma oreoboloides	2.241	Not Associated	Not Associated	0.124
Vaccinium sp.	4.698	Associated	**Positive**	0.164

On the case of the conservation status of *R. eymae* and *R. nanophyton* var. *nanophyton*, the earlier assessor (Gibbs *et al*., 2011), probably applied the precautionary principle when facing the uncertainty (IUCN Standard & Petitions Subcommitte, 2014). A precautionary principle is allowing the assessors to classify a taxon as threatened unless it is highly unlikely that it is not threatened (IUCN Standard & Petitions Subcommitte, 2014). Majorly, it comes when the assessments are based on partial information and often in data-poor situation. Gibbs *et al*. (2011) stated that those species were point endemic to the summit of Mt. Rantemario, but their also proved that they did not known of the current threats. At this point of view, the taxon more fitted under the status of Near Threathened (NT). However, they put those species as a threatened taxon. Probably, it was inferred from an event happened on the other tropical subalpine *Rhododendron* population in Mt. Kinabalu (Argent, 1992). Severe drought in 1982 have caused the population size of endemic *R. buxifolium* in Mt. Kinabalu to decrease to 25% of its previous size (Argent, 1992). Some of stochastic climatic events such as hurricane, global warming, and climate change are not included as a plausible threats except for the taxon with restricted distribution range (IUCN Standard & Petitions Subcommitte, 2014). There were some evidences that El Niño-Southern Oscillation (ENSO) caused severe drought season in Indonesia (Slik, 2004; Vicente-Serrano *et al.*, 2013). On the fact, the population of *R. eymae* and *R. nanophyton* var. *nanophyton* were distributed at 3,100–3,300 m asl and restricted only on the summit of Mt. Rantemario. Based on these evidence and the IUCN red list categories and criteria, the appropriate status for those two species is Vulnerable D2 rather than Endagered D.

Tropical alpine ecosystem is one of vulnerable ecosystem to climate change. Buytaert *et al*. (2011) stated that climate change will reduce the area of tropical alpine. It will lead on the increasing of isolation of the remaining alpine area that will induce the biodiversity loss. Based on orographic zonation (Van Steenis, 1936), alpine zone in Malesian region (Indonesia, Malaysia, Singapore, Brunei, Phillipines, Papua New Guinea) started at elevation of 4,000 m as a limit for treelines, while, subalpine vegetation started above 2,400 m. Therefore, the summit of the Mt. Rantemario classified as the upper zone of subalpine vegetation.

The vegetation composition of the upper subalpine zone varies among the mountains within the Malesia region. On Mt. Kerinci (Sumatera, 3,800 m asl), the vegetation above 3,200 m only covers 30% of the areas and plants are reaching height less than 50 cm. The dominant dwarfed shrubby plants were ericoid (*Rhododendron retusum, Vaccinium varingiaefolium*, and *Gaultheria punctata*), while the herbaceous species were *Histiopteris*, *Senecio,* and *Carex* (Ohsawa *et al*., 1985). On Mt. Pangrango (Java, 3,019 m asl.), the vegetation on the summit were dominantly occupy by shrub plants such as *Anaphalis javanica, Leptospermum flavescens*, and ericoid (such as *Vaccinium varingiaefolium* and *Gaultheria punctata*), while the herbaceous were grasses (*Tripogon exiguus* and *Isachne pangerangensis*) and *Carex* (Sadili *et al*., 2009). On Mt. Kinabalu (Borneo, 4,101 m asl.), the summit zone was started at 3,260 m that divided into seven parts. The upper mountain forests (3,260–3,550 m) have *Dacrycarpus kinabaluensis-Symplocos zizyphoides* association characteristics. The dominant trees in this vegetation were *Dacrycarpus kinabaluensis, Drymis piperita,* Myrtoid (*Euginia, Leptospermum recurvum, Schima wallichii*), and *Rhododendron buxifolium*. The dominant shrubs were *Symplocos zizypyoides, S. buxifolia,* and *Polyosma hookeri* (Smith, 1980). On Mt. Jaya (Papua, 4,884 m asl.), lower subalpine vegetations were dominated by trees (*Rhododendron culminicolum, papuacedrus papuana, Dacrycarpus compactus*), shrubs (*Rhododendron, Trochocarpa,* and *Rubus*), and herbs (*Deschampsia* and *Gleichenia*) (Hope, 1976). While in the summit of Mt. Rantemario (Sulawesi, 3,478 m asl.), based on the recent result, the vegetation was dominated by trees and shrubs of *Leptospermum javanica* and ericoid (*Styphelia suaveolens, Vaccinium* and *Gaultheria celebica*), and herbs such as *Eriocaulon truncatum* and poaceae (*Rytidosperma* and *Poa*). Those evidences have showed that ericoid and myrtoid plants are common on subalpine region of Malesia and it can explain why the *R. eymae*is associated with *Leptospermum javanicum*. On the other hands, *Rhododendron* and *Gaultheria* are common to occur in this habitat type but in Mt. Rantemario, *R. eymae* has negative association with *G. celebica*. There is no clear information why it can be. Probably, those two plants have different microhabitats, most of *R. eymae* individuals were found on soilless or rocky microhabitat, while *G. celebica* were found in contrast. However, it needs a further study.

Based on the vegetation composition, the subalpine flora of Mt. Rantemario has floristic affinities to both of western part and eastern part of Malesia region. The widespread species such as *Leptospermum javanica* and *Eriocaulon truncatum* distributed across the Wallacea line from Asia mainland to north Australia. The genus *Leptospermum* were much developed in Australia while the *Rhododendron* were more developed in Asia (Himalayan area). Van Welzen *et al.* (2011), stated that Sulawesi flora were included in the central Wallacea area that has more heterogenous flora than those of the western part (the Sunda shelves) and the eastern part (Sahul shelves) of Malesia.

Van Welzen *et al.* (2011) implied that Sulawesi is a distinct area by having many endemic taxa. In this view, many of endemic Sulawesi flora have a tendecy to retain ancestral ecological characteristics (niche conservatism). For example, *R. eymae* has never been successfull to introduce to *ex situ* habitats due to the specific microhabitat type (Argent, 2006). Thus, conservation based areas are more effective to conserve the flora, but we need a sample of species to monitor the conservation success. *R. eymae* and *R. nanophyton* var. *nanophyton* can be two of some suitable samples as the proxies of the vegetation sustainability.

CONCLUSION

The appropriate conservation category of *R. eymae* and *R. nanophyton* var. *nanophyton* should be Vulnerable D2 (VU D2). Those plants are point endemic to the summit of Mt. Rantemario. Five dominant plant species on the summits were *Leptospermum javanica*, *Eriocaulon truncatum*, *Styphelia suaveolens*, *Rytidosperma oreoboloides*, and *Gentiana* sp1. The *R. eymae* has positive association with *Leptospermum javanica* and *Gentiana* sp1, while *R. nanophyton* var. *nanophyton* has positive association with *Vaccinium* sp. Therefore, the best strategies to conserve those plants is plant community-based approach. This strategy can accommodate both of species-based and ecosystem-based conservation. Those endemic *Rhododendron* species seem to be suitable for Sulawesi tropical alpine ecosystem health indicator.

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