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Population, habitat characteristic, and modelling of Endangered Orchid, *Paphiopedilum javanicum* in Mount Lawu, Java, Indonesia

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Abstract. *Romadlon MA, Az Zahra F, Nugroho GD, Pitoyo A. 2021. Population, habitat characteristic, and modelling of Endangered Orchid,* Paphiopedilum javanicum *in Mount Lawu, Java, Indonesia. Biodiversitas 22: 1996-2004. Paphiopedilum javanicum* (Reinw. ex Blume) Pfitzer or Java Paphiopedilum is an endangered orchid categorized as appendix I in CITES. In its natural habitat, forest fire, habitat fragmentation, and extreme poaching are considerably the prominent threats for the species. The study aims to assess the population distribution, the habitat characteristics and model the suitable habitat of *P. javanicum* in Mount Lawu, Java, Indonesia using Maxent (Maximum Entropy) modelling. Eighteen subpopulations of *P. javanicum* spread across the region with a total number of 104 individuals. The majority of the individuals are in the generative phase (93.3%) and the rest are in the vegetative phase (6.7%). In Mount Lawu, *P. javanicum* can be found at an elevation of 1,231-1,825 m asl. in a deep shady forest floor with a thick litter and canopy cover between 0-77.4%. The soil has pH between 7-7.1 with 12.5-36.7% of moisture. The air temperature ranging between 21.8˚-29.7˚C, with humidity of 61-78.5%. Based on the Maxent test, annual mean temperature, vegetation cover, type of land use, and elevation are the most influencing factor of *P. javanicum* distribution in Mount Lawu. The model identifies 6814.75 ha areas in Mount Lawu that are suitable for the species distribution. Lawu Purba, the biggest suitable area for *P. javanicum* habitat in the southern part of the mountain holds the remaining natural forests in the region. The result is expected to provide recommendations for determining priority areas in the conservation efforts for this threatened orchid.

Keywords: Endangered species, habitat modelling, maximum entropy, Maxent, Mount Lawu, *Paphiopedilum javanicum*

INTRODUCTION

Orchidaceae is the most diverse plant family with 32,754 accepted species names worldwide (POWO 2021). The diversity of the orchid family is inseparable from the uniqueness of its generative propagation, symbiosis with microorganisms, and various types of habitats where they could grow. However, because it has an association with specific pollinators and microorganisms and limitation of germination, many orchids have limited distribution (Swarts and Dixon 2009; Wani et al. 2021). Some orchids species are becoming threatened by several factors, such as overgrazing, habitat loss, human intrusion, and over-exploitation due to increasing market demand in trading (Pant and Raskoti 2013; Agustini et al. 2016; Warghat et al. 2016).

One genus that often traded is *Paphiopedilum* as known as the slipper orchids (Bänziger et al. 2011). It is particularly popular as an ornamental plant, because it has beautiful flowers and attractive leaves (Vu et al. 2020). The main feature of *Paphiopedilum* is its pouch-like lip on the flower. Most of the *Paphiopedilum* species are threatened due to overexploitation, such as *P. armeniacum* and *P. druryi* (Bänziger et al. 2011). Many studies on *Paphiopedilum* have been carried out both in situ and ex situ for conservation purposes, such as *P. rothschildianum* (Rchb.f.) Stein in Kinabalu National Park, Malaysia (van der Ent et al. 2015), *P. fairrieanum* (Lindl.) Stein in Bhutan (Samdrup et al. 2020), and *P. javanicum* (Reinw. ex Blume) Pfitzer in Bali (Tirta 2011).

There are 3 species of *Paphiopedilum* in Java, namely *P. lowii, P. glaucophyllum,* and *P. javanicum* (Comber 1990). *P. javanicum* is one of the endangered species listed by IUCN Redlist (Rankou 2015) and included in the appendix 1 category by CITES (Govaerts et al. 2019). The population of this orchid in nature continues to decline due to various threats, such as habitat fragmentation, unsustainable hunting, and climate change (Rankou 2015). Insight into the population will help determine the number and level of mortality in nature. The distribution of *P. javanicum* is ranging from West Malesia to the Lesser Sunda Islands. In Java, *P. javanicum* can be found in the forest of Mount Lawu. The highest peak is at an altitude of 3,265 m asl. and has different environmental characteristics on each side. The forest areas in Mount Lawu are one of the few remaining tropical montane cloud forests (TMCF) in Java. Its vegetation is regularly covered by fogs that often turn to local raindrops (Ray 2013). The dense epiphytic plant communities on the crown of the vegetation are also one of the features of TMCF. TMCF is a rare and fragile ecosystem type but has a high level of species endemicity and has an important role in the hydrological system (Bruijnzeel et al. 2011; Ledo et al. 2012). The forest is also an important habitat for some endemic and threatened orchid species, such as *Pecteilis susannae*, *Dendrobium jacobsonii*, *Corybas umbrosus* including *Paphiopedilum javanicum*.

Information regarding the distribution of threatened species is critical information for conservation efforts (Radosavljevic and Anderson 2014; Štípková et al. 2020). This information can be obtained through modelling the distribution of the species. Techniques for making species distribution models have developed a lot and have been widely used (Peterson et al. 2011). One the commonly used is the Maximum Entropy (Maxent) software (Elith et al. 2011).

This study aims to figure out the population of *P. javanicum*, habitat characteristics and potential suitable habitat of *P. javanicum* in Mount Lawu, Java, Indonesia. The results of the study are expected to provide more insight into the suitable habitat and further recommendations for conservation priority for this threatened orchid in nature, especially in Mount Lawu.

MATERIALS AND METHODS

Study site

Mount Lawu is located at 07˚38'54" S 111˚11'13" E (Figure 1). The area covers five districts, i.e. Magetan, Ngawi, Karanganyar, Sragen, and small part of Wonogiri (Rumaisa and Fathullah 2019). Mount Lawu area consists of northside and southside, split by a cross-provincial road. The topography of the north side is cone-like, which is the Lawu Muda volcano, while the south side is the Lawu Purba volcano or Jobolarangan volcano and consists of small mountains that have many peaks (Freski et al. 2017).

The study sites are within two forest areas, i.e. (i) The conservation forest is under Great Forest Park (TAHURA) KGPA Mangkunegoro I management (230 ha), and (ii) the protection and production forest are managed by Indonesia Forest Agency (Perum PERHUTANI) (52,384 ha) which include Mount Lawu Muda and Mount Lawu Purba. According to van Steenis (1972), the average rainfall in all mountains in Java, including Mount Lawu, ranges from 2,000-3,000 mm per year. Mount Lawu can even reach 4,000 mm per year to be categorized as very high (Herawati et al. 2018). Current data indicate that the daily precipitation is 12.1-46.1 mm, the daily temperature is 23.9-24.1˚C, and the daily humidity is 75.6-93.7% (BMKG 2021).

Procedure

Field survey was conducted from December 2019 to March 2020 in the forest areas of Mount Lawu Muda and Mount Lawu Purba to observe and collect the population and habitat characteristic data of *P. javanicum*. Study plots of 20 x 20 m are built purposively on the locations where *P. javanicum* occurrence is reported from direct sighting or the information from the local community. Population pattern and size, individual spatial distribution, and life stage of each individual were recorded. Environmental factors such as: temperature, air humidity, soil pH, soil moisture, and canopy cover were measured to understand the habitat characteristic of *P. javanicum* in the research site. The coordinate of the plots was also tagged for further analysis on habitat suitability modelling. In total, 18 plots were made for the data collection (8 plots in Lawu Purba and 10 plots in Lawu Muda).

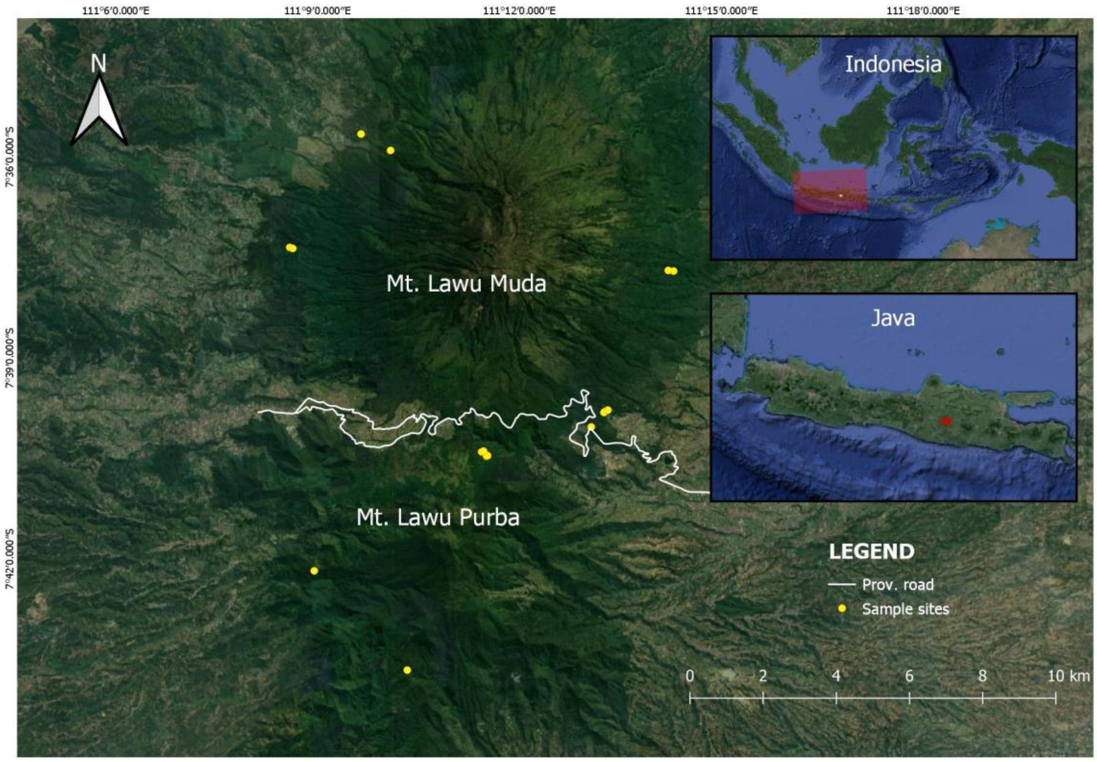

Figure 1. Research sites in two parts of Mount Lawu areas, Java, Indonesia

Four environmental variables were used in addition to encounter points in Maxent modelling. Annual mean temperature and annual mean precipitation variables were obtained from the Worldclim database version 2.0 released in early 2020 (https://www.worldclim.org/data/worldclim21.html). This data is the average data obtained from the years 1970-2000. The topographic variable collected for the analysis is altitude obtained from Worldclim version 2.1, derived from SRTM data (Fick and Hijmans 2017). All variables are in 30s resolution or also known as 1 km spatial resolution. Other environmental variables, land use, and tree cover were downloaded from http://land.copernicus.eu/ (Buchhorn et al. 2020). The Normalized Difference Vegetation Index obtained from http://earthexplorer.usgs.gov/. All environmental variables are processed with QGIS software v. 3.10 to be converted into ASCII (.asc) format for further analysis with Maxent software.

Data analysis

Population pattern was analyzed descriptively. Each subpopulation was counted, and individuals discerned the life stage (generative stage or vegetative stage) and the life growth (solitary or clump) in the plots.

The environmental variables were multicollinearity tested, to avoid potential correlations that will affect modelling accuracy (Zhao et al. 2020). The test also considers the Variance Inflation Factor (VIF) value. The VIF value can be used to detect collinearity between 2 or more variables (Naimi et al. 2014). If a correlation is found in the variables, then one of the variables that less significant must be removed (Latifiana 2018).

The correlation test and VIF test were carried out using the R software v. 3.6.1 by combining all rasters from six variables. The test used the 'layerStats' function for Pearson's correlation test and the 'vifcor' command by Naimi et al. (2014) for the VIF test with a threshold value of 0.8. Variables with a Pearson's correlation coefficient (PCC) $\leq$ 0.8, and VIF $>$ 10 were removed from the modelling. Two variables, tree cover, and annual mean temperature were removed from the model.

Maxent software v. 3.40 was used to build a habitat suitability model for *P. javanicum* in the Mount Lawu area. In this modelling, 80% of the encounter data is used for the training set and the rest for the test set.

The receiver operating characteristic (ROC) curve was used to measure the model's performance accuracy. ROC has an independent threshold measure, the Area Under Curve (AUC) value is effective in distinguishing attendance data from absence data (Xu et al. 2019) with a range of values: AUC $\leq$ 0.7, less good; 0.7 $<$AUC $\leq$ 0.8, moderate; 0.8 $<$AUC $\leq$ 0.9, good; 0.9 $<$AUC, excellent (Araújo and Guisan 2006). The output of the Maxent software is a prediction of habitat suitability with a value range of 0 (not suitable) to 1 (appropriate) (Phillips and Dudik 2008). Then the output (format: .asc) was advance processed using QGIS v 3.10 software.

RESULTS AND DISCUSSION

Population pattern

Paphiopedilum javanicum is a herbaceous plant that has rhizomes and short stems. The leaves have a mosaic pattern of dark green patches on the upper surface due to the uneven distribution of chlorophyll. The mosaic is specific for each *Paphiopedilum* species (Vu et al. 2019). In Mount Lawu, *P. javanicum* faces population and habitat problems. It is a target of poaching in the region and has been sold as an ornamental plant. Besides that, human population development and human activities which are not accompanied by conservation efforts have threatened the habitat of this species.

In total, 104 individuals of *P. javanicum* within 18 plots in the forest areas of Mount Lawu were found. The average number of individuals in a plot is 5.10 individuals. Based on life growth, the spatial distribution of the subpopulations was categorized as clumped (61%) and solitary (39%) (Figures 2 and 3). The spatial distribution pattern of a population provides information on the dynamic interaction that may occur in a habitat (Han et al. 2008; Bänziger et al. 2011). There are three basic patterns of spatial distribution, i.e. clumped, random, and regular (Barbour et al. 1987; Dale 2000). Most plant species tend to be distributed in clumped for easier propagation. Anchored colonies' roots will cluster tightly and accumulate clay and nutrient particles washed down by the water. It will provide food and nutrient for the colonies (Bänziger et al. 2011). Besides, the presence of colonies indicates that the area has a good microclimate for growth (Barbour et al. 1987; Engel et al. 2021), but they will increase the competition intrapopulation itself (Dale 2000; Bänziger et al. 2011).

The life stage of *P. javanicum* found were mostly in the vegetative phase (93.3%) and only a small portion in the generative phase (6.7%) (Figure 2). The plant indicates the generative phase begins to flower and bear fruit (Figure 4). In this phase, plants are in the stage of reproducing themselves through seeds. Ripe fruit will produce dust-like seeds and will fly or fall around the parent plant (Bänziger et al. 2011). The parent plant roots can hold the humus around the roots so that when the seeds are scattered around them, they will germinate easily with the help of mycorrhiza (Zhongjian et al. 2006; Bänziger et al. 2011). Mycorrhiza supplies carbohydrates and nutrients for orchid seeds. However, in *Paphiopedilum*, the success of seed germination was small less than one germinated plant from one capsule seed reaches maturity (Bänziger et al. 2011). Not only the generative phase, but the research also observed *P. javanicum* in the vegetative phase (Figure 4). *Paphiopedilum* produces tillers in two ways, firstly producing shoots from the base of the stem, and secondly, producing rhizomes that will produce new offsprings (Zhongjian et al. 2006). In this research, 29% of individuals in the vegetative phase shows emerging buds. Knowing the life cycle is essential because it can provide information about the demographic of adults and juvenile plants. *Paphiopedilum* will mature and ready to flower around the age of 4-5 years in the wild population, but the microclimate also influences this phenomenon. The flower only emerges once in a lifetime. The plant will wither afterward, but the environmental conditions influence the inflorescence. If environmental conditions do not meet the requirement for flowering, the inflorescence spans will be delayed and the plant begins to produce buds (Zhongjian et al. 2006; Bänziger et al. 2011).

Habitat characteristic

Paphiopedilum javanicum in Mount Lawu is distributed at an elevation of 1,231-1,825 m asl. Most individuals (65 individuals) are found at 1,400-1,600 m asl., 9 individuals at altitudes above 1,600 m asl., and 29 individuals below 1,200 m asl. All individuals are lithophyte or terrestrial type. They grow on rocky flat ground or steep slopes and the soil surface with thick litter layer or moss-covered ground. Naturally, variables that affect the distribution, richness, and abundance are the macro and microclimate, resulting from a combination between environmental factors and the altitude of the habitat (Zhang et al. 2015; Djordjević et al. 2016, 2020). Comber (1990) indicated that *P. javanicum* is mostly encountered at around 1,500 m asl. In Java, it can be found at 1,200-1,500 m asl. in Gede-Pangrango National Park (Prapitasari et al. 2020) and 1,700-1,800 m asl. in Mount Andong, Magelang (Aisah and Istikomah 2014).

The habitat of *P. javanicum* in Mount Lawu is in a forest with a temperature range of 21.8-29.7˚C, soil pH 7.0-7.1, humidity 61-78.5%, soil moisture 12.5-36.7%, and 0-77.4% of canopy cover (Table 1). The habitat characteristics are slightly different compared to the population recorded in Bukit Pengelengan (Bali) and Gunung Gede Pangrango National Park (West Java) that are found in temperature of 18˚-25˚C, soil pH 4.9-6, moisture 72-99%, and soil humidity 61% (Tirta 2011; Prapitasari et al. 2020). The result showed differences in temperature, air humidity, soil pH, and soil moisture. Many factors could affect the abiotic variables, such as the period of data collection, and study site (location and biotic factor) (Djordjević and Tsiftsis 2020).

Temperature is an essential factor in an ecosystem because the development of flowers and seeds is influenced by temperature. The optimum temperature for development varies depending on the species (Acharya et al. 2011). Soil pH also plays an important role. *P. javanicum* is a terrestrial orchid that uses rhizome or tubers to obtain nutrients from the soil. Appropriate soil pH will drive the orchids to avoid nutrient deficiency symptoms (Tagentju et al. 2020). The soil pH can be affected by organic litter on the ground (Mikkelsen 2005). Tirta (2011) suggested that good habitat is usually in a deep forest with 60% humus on the ground. Soil condition for *P. javanicum* habitat in a forest is ranging from pH 4.9-7, and soil moisture of 21.7-99%. *P. javanicum* also need appropriate air humidity and soil moisture in their habitat to minimize water loss (Djordjević and Tsiftsis 2020). The moisture in an ecosystem can be maintained by the vegetation cover. The canopy of vegetation reduces direct sunlight reaching the bottom of the forest (Tagentju et al. 2020). Among the encountered individuals, only one subpopulation was found in an open canopy area but still covered by other floor vegetation. The requirement of canopy cover of *P. javanicum* is similar to *P. armeniacum* (Zhongjian et al. 2006), and *P. lunatum* (Metusala 2017) ranging from an open canopy to a quiet shaded canopy cover.

Paphiopedilum javanicum in Mount Lawu is found in mixed forest, consisting of diverse trees, such as *Altingia excelsa, Schefflera polybotrya, Schima wallichii,* and *Lithocarpus* sp. Similar to its relative, *P. armeniacum* grows densely near the community of *Quercus* and herbaceous plants (Zhongjian et al. 2006). It needs more study whether the occurrence of *P. javanicum* has any association to the nearby plants.

Model performance and contributions of environmental variables

The use of variables that affect the distribution of a species is constructive in the modelling process (Phillips 2017). Several environmental variables that have the potential to influence the distribution of *P. javanicum* were tested and selected. After carrying out multicollinearity test with the R program, 4 environmental variables were chosen to model the suitable habitat of *P. javanicum* in Mount Lawu, namely annual mean temperature (b1), elevation (elev), land use, and the normalized difference vegetation index (ndvi). The results show that b1 and elev correlate. However, both are still used in the modelling because these two variables are important factors in the distribution of a plant species (Zuhud et al. 1998). Information on the relationship between environmental variables and species is vital to determine the ecology and distribution patterns of the species (Yi et al. 2018). Among the four environmental variables that have been used, b1 has the highest contribution percentage, followed by ndvi, land use, and the lowest is elev (Table 2). Maxent modified each single evaluation factor and coefficient adjustment to calculate the contributions of each environmental variable (Figure 5). Based on the contribution and permutation result, the b1 is the most important variable related to the distribution of *P. javanicum*. The AUC training value is 0.973, indicating that Maxent produces a good model that has high accuracy for habitat suitability (Figure 6) (Araújo and Guisan 2006). The AUC value is a ranking approach for assessing the model fit. It determines the probability of the present location will be ranked higher than a random background location (Phillips et al. 2006). The AUC value will be high for species with a narrow distribution range (Phillips 2017).

The Jackknife test was conducted to see the influence of each environmental variable in building the model (Figure 7). The figure showed that the most influential environmental variable on the model is elev and b1. This explains that these two variables have beneficial information in model building, then followed by ndvi and land use (Figure 7). However, removing either b1 or elev from the model does not significantly influence the training gain value. The score of both variables is consimilar. This is because both variables correlate. It makes the value of the training gain is divided into elev and b1 variables. Meanwhile, the land-use variable has the lowest effect. The training gain score is still high, even though the land use variable is not used.

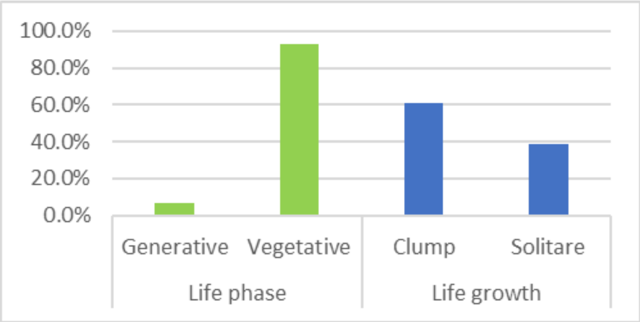

Figure 2. Percentage of population pattern

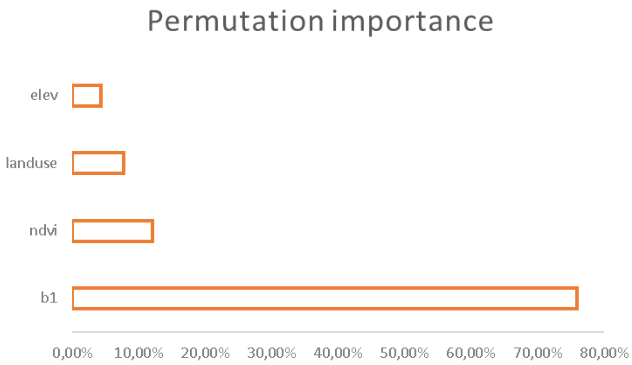

Figure 5. Permutation importance of variables for modelling

Figure 3. Life growth of *Paphiopedilum javanicum* A. Solitary, B. Clumped

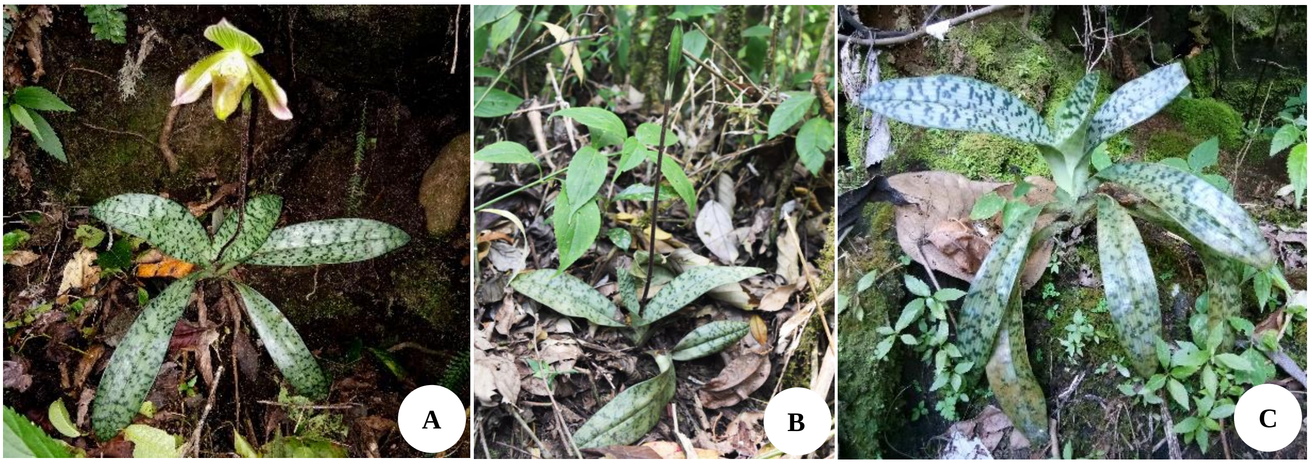

Figure 4. *Paphiopedilum javanicum* in Mount Lawu, Java, Indonesia: Generative phase: A. flowering stage, B. fruiting stage; C. vegetative phase

Table 1. habitat characteristic of *Paphiopedilum javanicum* in the research sites

Plot	Number of individuals	Temperature (ºC)	Soil pH	Moisture (%)	Soil humidity (%)	Canopy cover (%)	Elevation (m asl)
1	1	22.9	7.0	69.0	36.7	63.6	1780
2	1	23.4	7.0	71.0	33.3	72.9	1808
3	1	24.7	7.0	69.0	28.3	73.2	1810
4	5	27.0	7.0	63.7	26.7	54.0	1231
5	5	22.4	7.0	62.5	22.5	41.2	1303
6	2	27.0	7.0	69.7	23.3	73.6	1379
7	13	29.7	7.0	61.0	27.2	19.9	1450
8	29	24.1	7.0	78.5	23.2	49.4	1503
9	1	21.8	7.0	72.0	13.0	7.5	1737
10	1	24.3	7.0	76.7	21.7	77.4	1799
11	1	23.8	7.0	78.0	15.5	0.0	1825
12	18	24.4	7.0	78.0	25.2	39.7	1390
13	6	25.0	7.0	74.0	19.5	51.4	1417
14	1	24.5	7.0	74.7	29.0	52.8	1459
15	9	24.1	7.0	77.0	29.2	64.2	1482
16	5	24.5	7.0	72.2	22.0	75.1	1470
17	2	22.4	7.0	76.5	12.5	66.5	1493
18	3	22.2	7.1	75.2	17.0	66.3	1796
Average	5.7	24.2	7.0	71.9%	96.9%	54.1%	1563

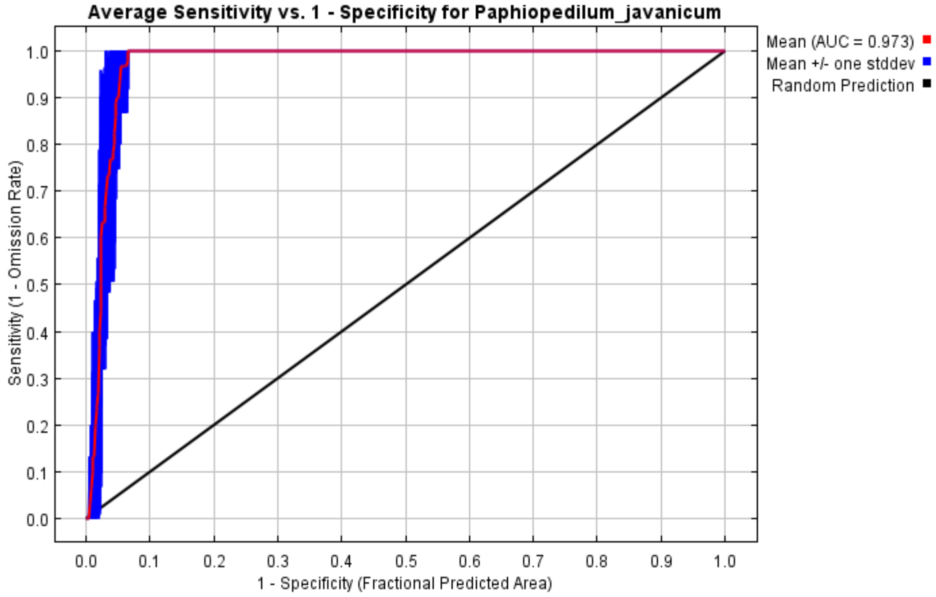

Figure 6. Reliability test of the distribution model created for *Paphiopedilum javanicum*

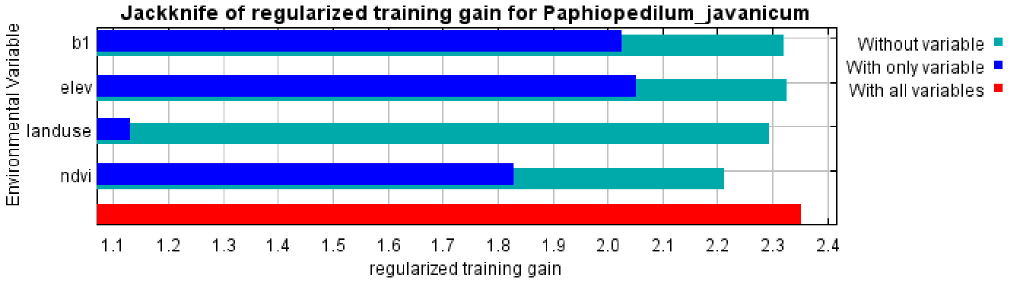

Figure 7. Jackknife of the regularized training gain for *Paphiopedilum javanicum*

Table 2. The contribution of each environmental variable in Maxent modelling

Variable	Contribution percentage (%)
b1	34.9
ndvi	26.9
land use	22.8
elev	15.5

Elevation and temperature are often the most determining variable in habitat modelling. Research conducted by Wani et al. (2021) showed the variable that influences habitat modelling of *Dactylorhiza hatagirea* is elevation. Kolanowska (2013) states that the most influential variable in habitat modelling of *Oeceoclades maculata* is temperature. However, it seems that the determining factor in habitat modelling is also species-specific. Precipitation is also important variable that influences habitat modelling in some species, such as *Arundina graminifolia* (Konalowska and Konowalik 2014), *Habenaria suaveolens* (Jalal and Singh 2017), and *Zanthoxylum armatum* (Xu et al. 2019). Other study presented that the Jacknife test for modelling *Rafflesia arnoldii* habitat is influenced by distance from the garden (Ellen et al. 2019). In selecting the variable used to build a model through Maximum Entropy, it is necessary to consider and adapt to species and required data.

Suitable habitat of *Paphiopedilum javanicum* in Mount Lawu

The model indicates that the total suitability of *P. javanicum* habitat on Mount Lawu is 6814.75 ha (computed by using QGIS v. 3.10) or 25.95% of the total area of Mount Lawu. The area is distributed on the slopes of Mount Lawu Muda and Mount Lawu Purba (Figure 8). These areas consist of mixed forest and production forest (pine trees). The area is often covered with fog and the natural mixed forest is recognized as Tropical Montane Cloud Forest. The widest suitable area is Mount Lawu Purba (41%). In Lawu Purba, the *P. javanicum* suitable habitat model almost covers the entire area. It is because of the similarities of the environmental condition of the habitat that occurred in the area. There are 8 encounter points of the *P. javanicum* population in Lawu Purba region. The topography of Lawu Purba influences the environmental condition of the region. It consists of a small mountainous range with plenty of peaks. Humid winds are coming all year round without obstacle and turn into raindrops making the region the main catchment area (Setyawan and Sugiyarto 2001).

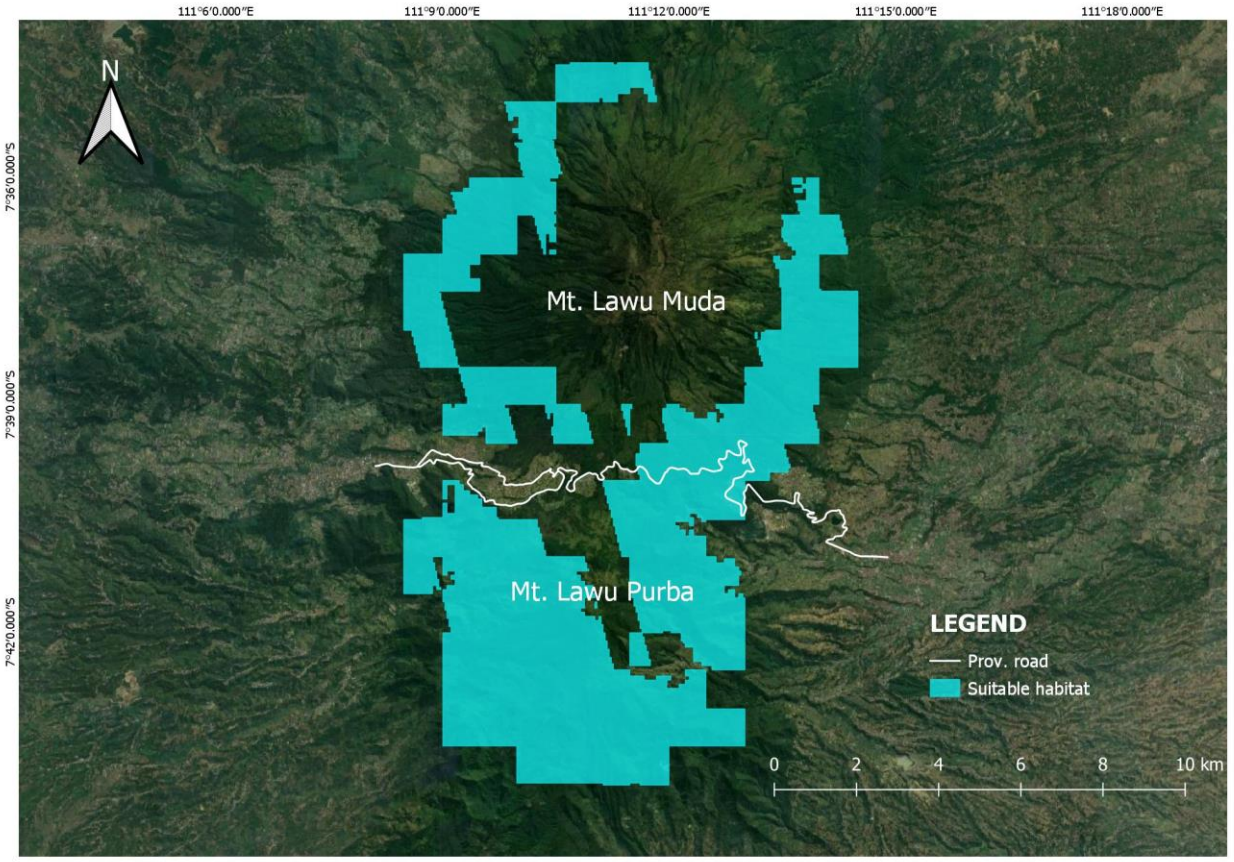

Figure 8. Suitable habitat model of *Paphiopedilum javanicum* on Mount Lawu, Java, Indonesia

Moreover, the forest type has a mixed forest that human activities have not fragmented. In Mount Lawu Muda, the suitable habitat for *P. javanicum* is only distributed across the slopes. The southern slope of Lawu Muda holds 22% of the total suitable habitat, the eastern slope provides 10% and the narrowest is on the northern slope that holds only 8%. The northern slope area has the narrowest suitability due to its environmental conditions, which tend to be arid areas, and in practice, there is no record of *P. javanicum* there. The north and east slopes generally have a hotter and drier environment because the humid winds from the southwest will turn dry when they reach the north and east slopes (Setiyadi et al. 2018). The land cover on the northern slope is mostly production forest consists of pine trees, savanna, and coffee plantation. Compared to other species, the total suitable habitat of *P. javanicum* in Mount Lawu is narrower than the suitable habitat of *Habenaria suaveolens* (Jalal and Singh 2017), and *Anoectochilus elatus* (Patil 2020). It depends on the study site and the variables were used in modelling.

In conclusion, 104 individuals from 18 subpopulations of *P. javanicum* were recorded in Mount Lawu. The population composition of *P. javanicum* in Mount Lawu is 6.7% in the generative stage and 93.3% in the vegetative stage. The distribution pattern shows 61% clumped and 39% solitary. The habitat of *P. javanicum* in Mount Lawu is in deep and shady forests with a thick litter layer and between 0-77.4% in canopy cover, soil pH of 7-7.1, soil moisture of 12.5-36.7%, air temperature range of 21.8˚-29.7˚C, and 61-78.5% in humidity. The environmental variable with the highest percentage contribution is the annual mean temperature, and the most influential in making the *P. javanicum* habitat suitability model is the elevation. The area of suitable habitat of *P. javanicum* in Mount Lawu obtained by Maxent modelling is 6814.75 ha and the most proportion is in the Lawu Purba region. Considering the threats, it is clear that preserving the area is important to protect *P. javanicum*. Beyond that, modelling the distribution of the species in other regions in Java is needed, considering *P. javanicum* is an endangered orchid species. A more complex study is also needed to advocate the conservation of the species and to provide more deep information about *P. javanicum* in its wild habitat.

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