Species diversity and threats on the habitat of Vatica javanica in the Ciangir Forest, Indonesia

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Abstract. Vatica javanica is one of the endemic dipterocarp species in Java. It is highly prioritized to be conserved and categorized as critically endangered A1cd, D ver 2.3 based on International Union for Conservation of Nature red list. There is still a lack of ecological study related to this Javan endemic dipterocarp. At the national level, V. javanica is categorized as critical EN A2cd; B2ab (ii, iii) ver.4.0. Information on the current population condition is essential to support the baseline data for the conservation effort of the species. To investigate the species diversity and threats in V. javanica's natural habitat, we established 26 transects of 20m x 50m based on the V. javanica occurrence and identified all the plant species (d= >1cm) composed V. javanica's population. V. javanica was only found at four out of 26 transects in the Ciangir forest, Kuningan District, West Java, Indonesia. The result showed that the species diversity in this population was very high, Simpson diversity index (α) = 0.96. Furthermore, based on the result of the critical value index (IVI), the population was dominated by V. javanica (20.97), Ficus sp. (11.01), Eurya acuminata (11.01), Dillenia obovata (10.72), and Lithocarpus sundaicus (10.31). This study identified that natural (landslides) and human intervention (land conversion) as the major threats for the species.

1. Introduction
Vatica javanica is a dipterocarp species that has two subspecies, javanica and schapifolia. Vatica javanica subsp. javanica from now on, referred to as V. javanica, grows specifically in Java, Indonesia. V. javanica is found in a protected forest at the border area between Capar village, Central Java and Ciangir village, West Java. This species is highly valued for its timber, similar to the other dipterocarp species. The previous study showed that this species only found in a specific block (block Cikadu) in the Ciangir forest [1]. Furthermore, this species grows in a particular location with high elevation (700 m above sea level) and steep slope [2].

V. javanica is categorized as critically endangered (CR) A1cd, D ver 2.3 based on IUCN red list categories and criteria. The criterion means there is a population reduction ≥80% over the past ten years or three generations; decline in area of occupancy, the extent of occurrence, and/or quality of habitat; actual or potential levels of exploitation; and population size less than 50 [3]. This species is poorly studied. Hence, there is no updating version of the categories since 1998. The complete criteria need to be added in detail with the latest version, including its geographic range, population, habitat and ecology, threats, use and trade, and conservation action.
Estimating species diversity is commonly used in conservation planning [4]. Figuring the patterns and drivers out that underlying the abundance and diversity of species encourages the ecology and evolution study [5]. Many factors are affecting the abundance and species diversity. The main threats to plant diversity are habitat loss, fragmentation, degradation, overexploitation, invasive species, pollution, and anthropogenic climate change [6]. Plant diversity significantly affects ecosystem functions and services [7]. Conservation of plant diversity through the combination of a well-designed and well-managed protected area system and ex-situ gap-filling and back-up should be applied in all places [6].

Ciangir forest is located in the Ciangir village, Cibingbin sub-district, Kuningan District, West Java province, and is managed by Perum Perhutani. This stated-owned forestry company operates mostly in Java. The forest is close to Capar village in which the area is prone to natural disasters. In addition to natural disasters, human threats are increasing as the forest area is close to the rural area. This study aimed to investigate the current population condition and its threats to formulate the conservation strategy of the targeted species.

2. Materials and Methods

2.1. Study site

This study was conducted in the Ciangir forest, Kuningan District, West Java, Indonesia (07º6'32"-07º6'28" S and 108º42'33" -108 º45'38" E) (Figure 1). The total forest area is 454.15 ha, classified as lowland forest and dominated by broadleaf evergreen forest. The elevation ranges from 400 to 1,100 m above sea level (asl), with the average precipitation is 3,000 mm per year.

![Figure 1. Map of study area and plot established in the Ciangir forest.](image)

2.2. Sampling design and measurement

We established 26 transects of 20 m x 50 m (Figure 2) considering the occurrence of *V. javanica*. After we found the targeted species, we established the transect perpendicular to the contour line included the targeted species and considering the access to the forest area. When we did not find the
species, we established transects on the area without the occurrence of the species considering the distance among transects.

We identified all plants with a diameter at breast height (DBH) >10 cm and counted them in the whole transects (20 x 50 m). To sample smaller individuals, we established smaller plots within transect: 5 x 10 m plots for individuals >5-10 cm in DBH and 5 m x 5 m plots for individuals >1–5 cm in diameter (Figure 2). We measured DBH and tree height. We used the diameter tape and the hypsometer to measure the DBH and tree height. Then, we took the plant samples to identify its scientific names.

2.3. Data analysis
For the species diversity, data were analyzed used the Simpson diversity index. Simpson diversity index required the abundance of one species and the number of species present.

\[ D = 1 - \sum \frac{N_i (N_i - 1)}{N (N-1)} \]

Data analyzed in descriptive qualitatively used the Importance Value Index (IVI). IVI consisted of relative density and relative basal area, according to Curtis and Cottam [8].

\[ IVI = \text{Relative density} + \text{relative basal area} + \text{relative frequency} \]

For the threats on V. javanica's natural habitat, we analyzed descriptively based on the field investigations and interviews with the key persons.

3. Result and Discussion
3.1. Population structure of V. javanica
A total of 285 individuals per hectare of V. javanica were found in four out of 26 transects that 4.9% of which were adults (DBH >30 cm). The population structure of V. javanica showed an inverse J-curved with a very high number of small individuals (1-5 cm in diameter classes) with a gradual decrease in the higher diameter classes (Figure 3). The same pattern of population structure was showed by Dipterocarpus littoralis, the other critically endangered dipterocarp species in Java [9]. The population structure showed a long-tailed on the right side of the graph. The graph indicated the high density of small individuals and gradually decreased in the bigger individual. The high density of small individuals showed that this population was on good regeneration and continually recruited [10, 11]; however, there was a possibility of disturbances on the bigger individual.
3.2. Species diversity, structure and dominant species

The calculation showed the Simpson diversity index ($\alpha$) = 0.96 in V. javanica's natural habitat. In this case, the value of the diversity index is close to one which represented greater diversity. The species richness also increases with the high value of diversity index, and there are no one single species, including V. javanica, dominated the population.

3.2.1. The total number of observed species amounted to 105 species with an average number of species for individuals >10 cm is 15 species per plot. Based on the result of the important value index (IVI), the population was dominated by V. javanica (20.97), Ficus sp. (11.01), Eurya acuminata (11.01), Dillenia obovata (10.72), and Lithocarpus sundaicus (10.31) (Table 1). V. javanica is one of the species dominated the forest as we found this species dominated the area but only on the specific area or transect. We used purposive sampling with the occurrence of V. javanica as the consideration in the formation of transects (purposive sampling), which are also the factors that influence the results of dominance. V. javanica trees seem to prefer to grow close to one another (clumped distribution). Overall, species domination was not high enough since the population has a diverse community.

Table 1. List of 20 most dominant species in the Ciangir forest based on the Important Value Index Calculation.

| Species                                  | IVI   |
|------------------------------------------|-------|
| Vatica javanica                          | 20.97 |
| Ficus sp.                                | 11.01 |
| Eurya acuminata DC.                      | 11.01 |
| Dillenia obovata (Blume) Hoogland        | 10.72 |
| Lithocarpus sundaicus (Blume) Rehder     | 10.31 |
| Macropanax dispermus (Blume) Kuntze      | 8.43  |
| Knema cinerea Warb.                      | 7.49  |
| Croton argyrous Blume                    | 5.43  |
| Castanopsis argentea (Blume) A.DC.       | 4.65  |
On average, the Ciangir forest had a density of $3,146 \pm 1,744$ individuals $\text{ha}^{-1} > 1 \text{ cm in diameter}$ and a density of $311 \pm 135$ individuals $\text{ha}^{-1} > 10 \text{ cm in DBH}$. Small individuals dominated the population in this forest represented a population with good regeneration (Figure 4). The average basal area of the forest was 25.07 m$^2$ $\text{ha}^{-1}$, with trees 10–50 cm and >70 cm in DBH contributing the most to the average basal area. Basal area related to the diameter value of a species in a community or population. Hence, the higher diameter of a species, its contribution to the average basal area will also increase.

| Species                                      | IVI |
|----------------------------------------------|-----|
| Mischocarpus sundaicus Blume                 | 4.63|
| Leea angulata Korth. ex Miq.                 | 4.02|
| Prunus arborea (Blume) Kalkman               | 3.94|
| Cinnamomum iners Reinv. ex Blume             | 3.91|
| Memecylon sp.                                | 3.77|
| Actinodaphne glabra Blume                    | 3.61|
| Sterculia oblongata R.Br.                    | 3.49|
| Xerospermum noronhianum Blume                | 2.82|
| Baccaurea sp.                                | 2.81|
| Nephelium lappaceum L.                       | 2.70|
| Syzygium glabratum (DC.) Veldkamp            | 2.68|

3.3. Threat on V. javanica’s population and its conservation strategy

The gradual decreased of the individual in a big diameter might indicate some disturbances in the population [12]. Both human and natural disturbances (for example, landslides) play an essential role in the decreasing number of big individuals. In the field, individuals with a diameter of around 20 cm commonly found cut illegally, but its utilization was still undetected. Furthermore, there was an indication of massive coffee planting under the forest stand, which could disturb the other plant growth in this forest, including V. javanica.

Near the forest area, around 50 m in the distance, there was a new tourist attraction in which forcefully closed due to the massive landslide on this location. It was obviously affected the current condition of the V. javanica population as they need to cut a particular area to establish the tower view.
and some small shops on this tourist attraction. It is good as the local authority closed the tourism activity in this area since late 2018 to prevent more destruction to the forest area.

The natural condition of *V. javanica*’s habitat, with its complicated topography, could maintain the diversity of the species in this forest. Complicated topography also became the main reason for the clump distribution of *V. javanica*. However, we should consider the threat of its complicated topography mainly from the natural disturbance, for example, landslides. Thus, ex-situ conservation is urgently needed to save and maintain some species outside their natural habitat for supporting an effort of protecting a threatened species in its natural habitat (in-situ conservation) [13, 14]. Conservation action has a positive impact on preventing species from extinction [15].

*V. javanica* is one of the critically endangered species in which we should be aware of its existence. This species only found in Java and previously reported exist in Priyangan in 1929. As the forest where the species occurs disturbed both naturally and unnaturally, the conservation strategy of this species is urgently needed. Ex-situ conservation is one of the options which could be chosen for rescuing this species. Many options of conservation effort involving local and national authority, and also the local community should be done as soon as possible. Cutting prohibition to the species in this forest, including *V. javanica*, must be implemented to prevent the more significant loss in the ecosystem.

4. Conclusion

The current population structure of *V. javanica* and its population follows inverse J-curve, which lacks individual on the big diameter. There are no single species dominated the population. Both human and natural disturbances threaten *V. javanica*’s population. Hence, both in situ and ex-situ conservation efforts are urgent needs to save the existence of *V. javanica* and its natural habitat.

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