Palm species diversity on Mount Slamet, Central Java, Indonesia

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Abstract. The palm plant group exists widespread in the world, including in Indonesia. The palm population occupies limited and specific scope areas. Palm diversity on Mt Slamet of Central Java, Indonesia, has not been reported. This study aimed to reveal the existence of palm diversity that occupies different sides of Mt. Slamet, i.e., the southern, the eastern, the western, and the northern slopes. The method used purposive sampling consisting of 236 10x10-m-plots on the palm population found along the climbing path of the four sides. The results showed that the diversity of the palm within each slope was significantly different. The palm diversity on the southern slope reveals the highest species richness and abundance with Pinanga javana. However, there is no single palm population existing on the eastern slope. The palm population on the western and northern slopes was not significantly different because of the similar number of species found. The southern slope has more stable microclimate factors, such as rainfall and temperature, that support the conclusion that the habitat on the area is in the most stable condition for the palm population.

Keywords: Diversity, Population, Palm, Mt. Slamet, Java.

1. Introduction

The palm group (Areccaceae family) has 182 accepted genera [1]. Indonesia is one kind of region that has the highest palm diversity [2-4]. Based on the abundance of the palm, Indonesia has 576 species. It distributes evenly from Sumatra to Papua. In this study, the research location chosen as the site is Mt. Slamet is one of the natural habitat distributions of palms.

Mt. Slamet is one of the tropical montane ecosystems in Java, with a varying height range for each slope [5]. Perum Perhutani applies three-category measures to manage the forest area on Mt. Slamet, namely production forest, limited production forest, and protected or natural forest. In detail, the management of Mt. Slamet forest is divided by KPH Banyumas Timur covering 46,453 Ha (include Cilacap, Banyumas, Purbalingga, and Banjarnegara Regency) and KPH Pekalongan Barat covering 40,743 Ha (include Brebes, Tegal and Pemalang Regency) [6].

The comprehensive information about the presence of palm in Mt. Slamet was limited. The previous study was restricted to the southern slope population and could not be comprehensively analyzed [7] due to the lack of similarity data obtained. Also, note that Mt.Slamet forest is essential to conserve many plant species, especially endemic species such as Pinanga javana Blume [4,8-10].
Therefore, this research aimed to reveal the existence of palm diversity that occupies Mt. Slamet from various sides (the southern, the eastern, the western, and the northern slopes). This research will provide detailed scientific information related to the palm diversity on Mt. Slamet. This research also finally provides essential information related to the best ecosystem of the four slopes on Mt. Slamet based on the richness of palm species and the abiotic factors.

2. Study Site and Methods
2.1. Study area
The study used the explorative purposive sampling method [11] on the four slopes of Mt. Slamet from July to August 2019. These slopes fall into different administrative areas, the southern slope (Banyumas Regency), the eastern slope (Pemalang and Purbalingga Regency), the northern slope (Tegal Regency), and the western slope (Brebes Regency) (Figure 1).

2.2. Population structure
The study employed the purposive sampling method to the palm population and measured the environmental variables in a plot of 10 x 10-m²-dimension [12]. All palm species were recorded, measured, and pointed with Garmin GPS 73 (Global Positioning System). Measurement of palm attributes included palm densities, stem diameter at breast height (dbh). Stem height and diameter were measured by a digital hagameter and a diameter tape, respectively.

2.3. Data analysis
The palm population was descriptively presented based on the plant species location. Palm species richness and relative abundance were calculated in each slope of Mt. Slamet. The Morisita Index (Iσ) is used to analyze data of distribution patterns [13].
3. Results and Discussion

3.1. Palm diversity on the Mount Slamet

The results showed that the population structure of palms in Mount Slamet consisted of 11 palm species, of which were five erect palm species and six rattan palm species (Table 1). Table 1 provides information on the common names and utility of each palm. Most of the palms found, such as rattan palm, are utilized for furniture, but the erect palm can also be used as ornamental plants. In addition, Table 1 also provides information on the distribution pattern of palms. In general, the majority distribution pattern is clustered in groups (8 species) ($\sigma_1 = 1$), and the other three species distribute uniformly.

| No. | Species                              | Common name         | Utilization               | $\sigma$ | Classify | Erect palm | Rattan palm |
|-----|-------------------------------------|---------------------|---------------------------|---------|----------|------------|-------------|
| 1.  | Calamus asperimus Blume             | Rotan cacing; Penjalin | Furniture                 | Cl      | -        | √          |             |
| 2.  | Calamus heteroideus Blume           | Rotan lilin; rotan cacing; Uwi sabut lilin | Furniture                 | Cl      | -        | √          |             |
| 3.  | Calamus unifarius H. Wendel         | Penjalin bandil      | Furniture                 | Cl      | -        | √          |             |
| 4.  | Calamus javensis Blume ex Mart.     | Rotan cacing; Rotan lilin | Furniture household      | Cl      | -        | √          |             |
| 5.  | Caryota maxima Blume ex Mart.       | Genduru; Sarai       | Building material         | Ud      | √        | -          |             |
| 6.  | Caryota mitis Lour.                 | Semangkung; Mpire    | Ornamental plant          | Cl      | √        | -          |             |
| 7.  | Calamus ruber Reinw. ex Mart.       | Rotan teretes, Penjalin | Furniture household      | Cl      | -        | √          |             |
| 8.  | Pinanga javana Blume                | Pinang jawa; Njawar  | Ornamental plant, alternative food | Ud      | √        | -          |             |
| 9.  | Pinanga coronata Blume ex Mart.     | Piji                 | Ornamental plant          | Ud      | √        | -          |             |
| 10. | Plectocomia elongata Mart. ex Blume | Buai, Penjalin warak | Building material (roofs) | Cl      | -        | √          |             |
| 11. | Salacca zalacca (Gaertn.) Voss      | Salak               | Fruit                     | Cl      | √        | -          |             |

Note: Cl: Clustered ($\sigma_1 = 1$); US: Uniformly distributed ($\sigma_1 < 1$)

Figure 2 reveals palm diversity on each slope, where the highest palm species richness is on the southern slope. The number of palms on the southern slope has ten palm species, differing from the number of palms on the western slope and the northern slope, decreasing less than half of the palm found. Subsequently, the number of palms on the eastern slope showed a surprising result not found at all palms. The results of the abundance of palm species are dominated by Pinanga javana, Pinanga coronata, and Plectocomia elongata (Figure 2 & 3). Unfortunately, in this study, no other palms such as Nenga pumila, Arenga pinnata, Korthalsia junghuhnii, or Calamus melanochaetes. Even though these palms occupy the southern slopes [14,15], this may be because of the methods used.

The number of palm on Mt. Slamet was smaller than that other similar studies conducted on Mt. Halimun, and it has been revealed that the type that dominates at that location is Calamus spp. [16,17]. The diversity of palm on Mt. Halimun has 21 species consisting of eight species of Calamus, four species of Daemonorops, two species of Pinanga, two species of Caryota, and each one species of Korthalsia, Licuala, Nenga, Plectocomia, and Salacca [16]. Likewise, with the palm inventory in Bodogol forest, Mt. Gede Pangrango National Park, where the palms found were 19 species [18]. The level of palm diversity at Mt. Slamet is lower than Mt. Halimun and Mt. Gede Pangrango may be due to differences in environmental factors such as rainfall, humidity, and temperature. The annual rainfall in Mt. Slamet ranges from 2,060-2,250 mm/year [19], while at Mt. Halimun and Mt. Gede Pangrango ranges from
3,000-4,200 mm/year [20,21]. Therefore, the condition of wetter environmental factors may be a specific habitat preference for palms.

![Figure 2](image)

**Figure 2.** Overview of palm species richness in four slopes of Mt. Slamet (right); Diagram of palm species abundance in Mt. Slamet (left).

![Figure 3](image)

**Figure 3.** Palm species that have a high abundance on Mt. Slamet.

In addition, the genus *Pinanga* consists of erect palms, diminutive or robust palms. This genus is distributed from the Himalayas, Southwestern China, and evenly distributed throughout Indonesia [3]. The stem of *Pinanga* is very slender to moderate, with elongate or short internodes and conspicuous leaf scars, occasionally stilted. The leaves are undivided and pinnately ribbed, with or without an apical notch or pinnate; tubular sheaths. The inflorescence is mostly infrafoliar. The pistillate flowers are borne through the rachillae and seed with basal hilum [3]. Approximately 40 species of *Pinanga* genera are distributed in Indonesia, 14 of which are endemic species[8]. Dransfield (1980) and Uhl et al. (1987) revealed *Pinanga* diversity's centre in Borneo Island, including Malaysia and Brunei Darussalam [22]. This study found that civet droppings consist of these palm seeds that suggested both palms have seed dispersing agents called common palm civets.
Afterward, *Calamus* is the genus with the highest number of species found on Mt. Slamet, consisting of five species, *i.e.*, *C. unifarius*, *C. heteroideus*, *C. asperrimus*, *C. javensis*, and *C. ruber*. The discovery of *Calamus* is also almost similar to the inventory of *Calamus* spp. on Mt. Halimun [16]. However, *Calamus* spp. has been claimed as the dominant palm in Mt. Halimun [16]. Globally, the *Calamus* has a wide distribution, occurring in the humid tropics of Africa to Indonesia. The best diversity and number of species in the Sunda Shelf area, especially Borneo, with a second centre of diversity in New Guinea. The habitat of *Calamus* is evenly distributed from seasonally dry habitats such as the monsoon forest. It can survive too in sub-mangrove conditions. Besides, *Calamus* can reach up to 3.000 m asl [23].

Interestingly, the genus variable is mostly climbing palms. It has a common name as a rattan palm. The stem eventually becomes bare, with short to long internodes, sucker shoots strictly axillary [3]. In addition, many species of *Calamus* spp. are also often used for bracelets and rings [17,24,25]. Furthermore, the genus included in other rattan palms is the genus *Plectocomia*. *Plectocomia* genus is rattan palms which is a clustering high-climbing. This rattan palm is distributed from Southeast Asia until West Malesia [23,26]. The stem of the palm is eventually becoming bare and sometimes bearing multiple. The leaves are pinnate and cirtate. The inflorescence produces simultaneously in the axils. The seeds attach to near the base, and the sacotesta is thick but not juicy.

The other genus has spines, but it does not belong to the rattan palm group, namely the *Salacca* genus. The genus *Salacca* is usually acaulescent, clustered, spiny, pleonastic, dioecious palms. It has been distributed in Southeast Asia and West Malesia [3,26]. The stem of *Salacca* is decumbent or very short and erect, usually obscured by the leaf bases. The internodes are short. The leaves are tiny to robust and pinnate. The inflorescence is axillary but enclosed within the sheath of the subtending leaf.

Finally, the last genus discovered was the genus *Caryota*. This genus is a solitary or clustered palm genus, monocious hapaxanthic palms. The genus has a moderate to a large stature. The stem of Caryota has internodes, obscured at first by persistant fibrous leaf bases and sheaths. The leaves are induplicate pinnate (except in juvenile phases where pinnate), marcescent or abscising under their weight—the bisexual, solitary inflorescence, produced in a basipetal sequence, interfoliar, and sometimes infrafoliar. The seeds are basally attached and irregularly spherical or hemispherical. This genus has a distribution area in the Southeast Asia region, Malesia to Australia [3]. This genus is often known as fishtail palms.

### 3.2. Palm Distribution on each slope of Mount Slamet

#### 3.2.1. The northern slope

The northern slope was located in Tegal Regency (Guci). The population of palm was found only four species (Table 2). Table 2 shows that the largest number of individual palms is owned by *Pinanga coronata* (92 individuals). In addition, it was also explained that the palm population on the northern slope mostly grows in the shade – an open area.

| No | Species                        | Population | Total | Habitat                      |
|----|--------------------------------|------------|-------|------------------------------|
|    |                                | Adult | Juvenile Seedlings |     |                              |
| Primary Forest |                               |       |                   |     |                              |
| 1.  | *Pinanga javana* Blume         | 2     | -                 | 2   | Hillslope                    |
| 2.  | *Pinanga coronata* Blume ex    | 87    | 5                 | 92  | Open area – under the canopy |
|    | Mart.                          |         |                   |     |                              |
| 3.  | *Calamus unifarius* H. Weindl | -     | 2                 | 2   | Hillslope – edge forest      |
| 4.  | *Caryota maxima* Blume ex      | 1     | 5                 | 14  | Open area – under the canopy |
|    | Mart.                          |         |                   |     |                              |
| Secondary Forest |                              |       |                   |     |                              |
| 1.  | *Caryota maxima* Blume ex      | 1     | -                 | 1   | Open area – under the canopy |
|    | Mart.                          |         |                   |     |                              |
| 2.  | *Pinanga javana* Blume         | 1     | -                 | 1   | Above waterfall              |
The research here began from an altitude of 1200 m asl (entered the forest area). Mostly, the palms are found in primary forest areas (protected forests). Secondary forests are dominated by Pinus merkusii. Interestingly, Pinanga javana that found above the waterfall. The growth of it indicated that the seed of Pinanga javana is dispersed by water. It also indicated that the growth of P. javana needs high humidity. Another out of interest is the growth of Pinanga coronata which is grouped in 1 location, namely at the point of the two hillsides. Even the local people named this location Pondok Piji (Piji is the local name of P. coronata). In addition, it should also be noted that the number of individuals of P. coronata in one clumping is around 5-10 individuals. Flowering and fruiting that occur throughout the annual and ease of regeneration (via buds) make this species very abundant and there are still many more possibilities because not all locations are touched because of my limited resources. The growth of P. coronata can survive under heavy shade [27]. Afterward, the seed dispersal of Caryota maxima that grow on their own in the Pinus merkusii forest (secondary forest) is carried out by animals that could be suspected as civets, bats, or squirrels.

3.2.2. The western slope
The western slope was located in the Brebes Regency (Kaligua), where the palm inventory began at 1900 m asl. The starting point is interesting because it includes the highest point of all slopes. It happens because the land was converted into a tea plantation and agricultural land was relatively high. Even in the last village, there is a height at the sub-village Kali Kidang, village Pandandari. Unfortunately, the palms found are only a few. There are only two species, Pinanga coronata and Caryota maxima (Table 3). It is certainly a critical note that the palm group may have habitat fragmentation on the western slope.

Table 3. Palm population in the western slope.

| No | Species               | Population | Total | Habitat                          |
|----|-----------------------|------------|-------|----------------------------------|
|    |                       | adult      | juvenile seedlings | Edge of forest (tea plantation) – open area |
| 1. | Pinanga coronata Blume| 1          | 1      | 2                               |
| 2. | Caryota maxima Blume ex Mart. | 5          | -      | 5 Under canopy                   |

3.2.3. The southern slope
The southern slope is located in the Banyumas Regency (Baturraden). The study began at 800 m asl. Bypassing the Agathis alba (secondary forest) and then entering the primary forest. This slope can be categorized as the best slope for the growth of the palm group. The number of palm species found is the highest among others. It is different from the research before, which revealed that the population of P. javana on the southern slope of Mt. Slamet has an IVI (Important Value Index) of 16.70% or only about 29 species from 70 observation plots [7]. These phenomena occurred because of the apparent differences in data collection methods. In this study, purposive sampling was based on found palm, while they used the transect method and were limited to height [7].

It is seen that the number of palms species in the southern slope is the largest of palm species richness with ten species. This condition is possible due to differences in the microclimate of the south slope with other slopes. This slope showed high rainfall and lower temperatures than others [9,10]. In contrast, the eastern slope exhibits that the palm population is the lowest (no palm population). Meanwhile, the northern and western slopes provided reveal that the palms do not differ significantly in number. In detail, the palm population on the southern slope has two main distribution criteria, secondary forests and natural forests. Table 4 provides information that the dominant palms found were P. javana (1683
individuals) and *P. coronata* (435 individuals). Most of the *P. javana* population is known to grow on hill slopes.

Interestingly, the population of *P. javana* in secondary forests dramatically plunged to only two species. Based on field study, this phenomenon is thought to be caused by the specific growth requirements of *P. javana*, which prefers hill slopes. At the same time, conditions in secondary forests tend to be flatter. Furthermore, the populations of *P. javana* dramatically decreased in the juvenile phase. Therefore, the number of adult *P. javana* reaches a high population. It is thought to occur because of predator seedlings so that their growth decreases in the juvenile phase. It also revealed that the growth of *P. javana* in Mt. Slamet needs specific recruitment for its establishments, such as abiotic factors such as slope, litter thickness, and coverage [7,8].

**Table 4. Palm population in the southern slope.**

| No | Species | Population | Total | Habitat |
|----|---------|------------|-------|---------|
|    |         | Adult      | Juvenile | Seedlings |         |
| Primary forest |          |            |        |          |         |
| 1.  | *Calamus asperimus* Blume | 10 | 25 | - | 35 | Hillslope |
| 2.  | *Calamus heteroideus* Blume | 19 | - | - | 19 | Open area – under the canopy |
| 3.  | *Calamus javensis* Blume | 20 | 9 | - | 29 | Open area – under the canopy |
| 4.  | *Caryota maxima* Blume ex Mart. | 14 | 5 | - | 19 | Under the canopy |
| 5.  | *Caryota mitis* Lour. | 5 | - | - | 5 | Under the canopy |
| 6.  | *Calamus ruber* Reinw. ex Mart. | 22 | - | - | 22 | Climber to host tree |
| 7.  | *Pinanga coronata* Blume | 156 | 56 | 223 | 435 | Open area – under the canopy |
| 8.  | *Pinanga javana* Blume | 1023 | 11 | 526 | 1683 | Under the canopy – dominant in hillslope |
| 9.  | *Plectocomia elongata* Mart ex Blume | 48 | - | - | 48 | Open area (climb to host trees) |
| 10. | *Salacca zalacca* (Gaertn.) Voss | 3 | - | - | 3 | Under the canopy |

**Secondary forest**

| No | Species | Population | Total | Habitat |
|----|---------|------------|-------|---------|
|    |         | Adult      | Juvenile | Seedlings |         |
| 1.  | *Pinanga coronata* Blume | 23 | - | - | 23 | Open area – under the canopy |
| 2.  | *Pinanga javana* Blume | 2 | - | - | 2 | Riverside |
| 3.  | *Plectocomia elongata* Mart. ex Blume | 15 | - | - | 15 | Open area (climb to host trees) |
| 4.  | *Caryota maxima* Blume ex Mart. | 4 | - | - | 4 | Under a canopy of *Agathis alba* |

### 3.2.4. The eastern slope

The eastern slope is on the Bambangan, administratively included in Purbalingga and Pemalang Regency. The study was started at an altitude of 1600 because this height is the boundary of the forest area. The primary vegetation of this slope is *Pinus merkusii* (production forest). Unfortunately, the results of tracing palms on this slope indicate no palm population. This condition may be because this area has dry characteristics, and the rainfall is relatively lower than other slopes.

In addition, the plant species typical of marginal land or pioneer plants dominate the vegetation population. For example, the vegetation found includes *Imperata cylindrica*, *Chromolaena odorata*, *Melastoma malabathricum*, *Lantana camara*, *Impatiens platypetala*, *Crotalaria linifolia*, and others. Furthermore, the condition of land conversion also occurs, which causes residential and agricultural areas to reach an altitude of 1600 m asl (Figure 4).
4. Conclusion
This study concludes that palm diversity in Mt. Slamet consists of 11 species distributed over four slopes. The distribution pattern of each species is mostly distributed in groups. The highest palm population found was the *Pinanga javana*, with an even distribution pattern of 1685 individuals. This study also concludes that stable microclimate conditions will be found in diverse and abundant palm populations, such as on the southern slopes. The following research opportunity is to uncover the diversity of palms on the other side that has not been reached. Furthermore, land conversion is a severe threat in the future, not only for the palm population but also for other plant populations. Therefore, relevant stakeholders must make severe commitments to protecting the area and implementing fundamental conservation pillars in conservation efforts.

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