

# Population Study of Endemic Java Palm *Pinanga javana* in Mount Ungaran, Semarang, Central Java, Indonesia

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**Abstract.** The discovery of *Pinanga javana* Blume in Mount Ungaran is new information for the distribution of this palm because there was no record of this palm on Mount Ungaran. Therefore, to reveal the population of *P. javana* in Mount Ungaran, this research was carried out to determine the population structure and habitat preference of *P. javana*. The study for *P. javana* was conducted using the focused survey method to explore all the side of Mount Ungaran (northern, southern, western, and eastern). The total area explored is 13 locations. All palm individuals have been recorded for diameter, height, and habitat. The results showed that from 13 locations, the population of *P. javana* was only found in 5 locations. Mainly on the southern side of Mount Ungaran. The total population of *P. javana* is around 213 individuals. The highest number of individuals is in the seedlings stage. The population of *P. javana* found is mostly on steep slopes compared to ridges that tend to be flat. In addition, the suspected habitat as a specific preference is the position of the slopes that are closer to the water source (river). The study also found that the distribution of *P. javana* was assisted by a dispersal agent (forest civet). In general, this study provides new information for the distribution records of *P. javana* in Java. Therefore, in this palm conservation function, special efforts are needed to increase the population of *P. javana* on Mount Ungaran.

**Key words:** endemic, habitat, java palm, mount ungaran

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## INTRODUCTION

Mount Ungaran is one of the most explored and hiked Mountains in Central Java Province, Indonesia. The forest cover is estimated to be 5.500 hectares in Mount Ungaran (Utami et al., 2019). The majority of the forest is managed by Perhutani, and these areas are classified into protection forest (2670.25 ha), production forest (622.33 ha), and limited production forest (618.93 ha). There is only one conservation area in Mount Ungaran, namely Gubungan Nature Reserve. This Nature Reserve covers only 1.8 ha and it is currently under the management of BKSDA - Central Java Province (Natural Resources Conservation Center), Ministry of Environment and Forestry. Mount Ungaran is reported to have a high level of biodiversity, mainly plant species (Rahayuningsih et al., 2017; Hidayat et al., 2018).

The discovery of *Pinanga javana* in mount ungaran is new information about the distribution of this species (new locality). The genus *Pinanga* has a widespread distribution from the Himalayas, the south-western part of China to New Guinea, and consists of 132 species (Govaerts & Dransfield, 2005). The center diversity of this

genus is in Borneo, with at least 45 species. In Indonesia, there are approximately 40 species of *Pinanga*, of which 14 are endemic to several islands (Witono et al., 2006). *P. javana* is one of the endemic palm species of the Arecaceae family found on Java Island.

*P. javana* is classified as Endangered by the IUCN Red List 1997. The species is also listed as protected species in the Minister of Environment and Forestry Regulation Number 106 of 2018. The species has several local names in Java, such as *Njawar* (Central Java), *Palem Barong* (East Java), and *Hanjawar* (West Java) (Zulkarnaen et al., 2019). *P. javana* distribute mostly in West and Central Java at an elevation between 800-1.700 m asl. A population study of this species has not much been done. A recent report that focuses on the population of this species was done by Zulkarnaen et al. (2019) in Mount Slamet, Central Java. Other studies were done by Moge (2004) in Mount Halimun Salak, Wihermanto (2004) and Alandana et al. (2015) in Mount Gede Pangrango, and Witono (2006) in many locations focused on the diversity of palms, dispersion pattern of *P.*

*javana* and genetic diversity of *P. javana*, respectively.

This study aims to assess the population and habitat preference of *P. javana* in Mount Ungaran. Therefore, information about this species population, abundance, and habitat requirements will be presented in this paper. The results will provide recommendations to the management authority for developing a conservation strategy for *P. javana* in Mount Ungaran.

## METHODS

### Study site

The study was conducted in Mount Ungaran, Central Java Province, Indonesia (Figure 1). The time of the study was in June – September 2021. Research locations were carried out on all sides of Mount Ungaran (Northern, Southern, Western, And Eastern). Mount Ungaran area covers several areas of Semarang Regency, including West Ungaran District, Bergas District, Bandungan District, Sumowono Regency, and Kendal Regency, including Limbangan and Boja District.

Pangrango, Mount Halimun-Salak, Mount Ciremai, Mount Willis, Mount Sawal (Ciamis), and Mount Slamet (Witono et al., 2006; Zulkarnaen et al., 2019; GBIF, 2021).

### Samplings

The study for *P. javana* was conducted using a focused survey method (Brewer, 2013). This method focused on the intensity of surveys on areas with high potential habitats for the targeted species. In each location where the species was found, site characteristics (elevation, slope, aspect, soil pH, soil humidity, temperature, air humidity, and topography), geographical location, number of individuals, and any apparent threats were recorded. Data of all parameters were subsequently processed to provide information on the condition of the habitat where the species lives. Total visited locations were 13 locations which represent all sides of the mountain. Sampling was started when *P. javana* was found. An individual with inflorescence or fruits was recorded and assigned as a mature palm. The population structure of *P. javana* was recorded.

**Table 1.** The categories of stage structure

Stage	Criteria
S1	Stem invisible, leaf length < 100 cm
S2	Stem invisible, leaf length > 100 cm
J1	Stem visible, leaf scars conspicuous, crown shafts developed, and the stem height < 50 cm.
J2	Immature individual with stem height > 50-100 cm
A1	Young mature individual with stem height > 100-200 cm
A2	Mature individual with stem height > 200-300 cm
A3	Old mature individual with stem height > 300 cm

Source: Ratsirarson et al. (1996).

### Species target

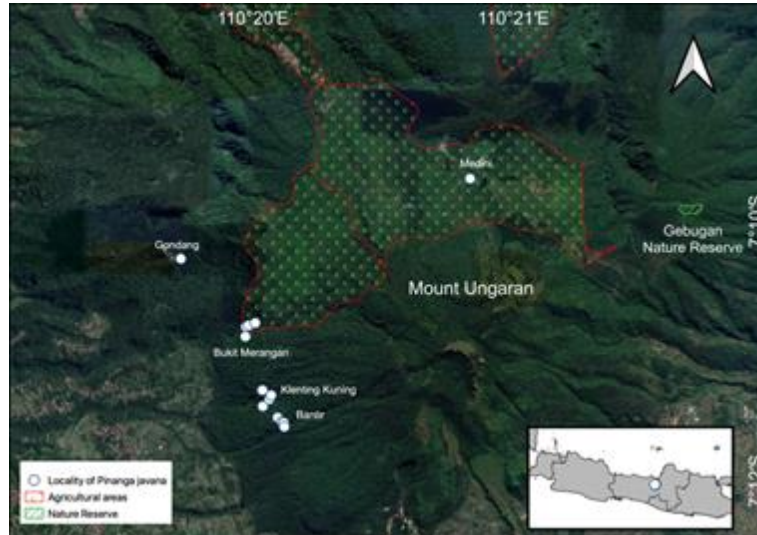
*Pinanga javana* is a solitary palm (not clumped). Its stem is erect, 4-10 m tall, 10-15 cm diameter. Crownshaft elongate, 150-200 cm long, 25 cm in diameter, swollen, purplish brown, and brown scales. Leaves 10 in the crown, pinnate; whole leaf (including leaf-sheath, petiole, and rachis) 250-300 cm with silvery indumentum on petiole and rachis, very massive. Inflorescence infrafoliar, hand-like, spreading pendulous, 40-50 cm long, peduncle erect at the base, flattened, 9-16 cm long, 0.8-1.5 cm thick (Witono et al., 2002). The distribution of this palm is limited to the island of Java. Until now, the distribution record of this species recorded in Mount Gede

### Stage structure

Stage structure was classified into seven different stage classes within the populations depending on the size of the leaves for seedlings and the height of the stem for juvenile and mature (Table 1).

### Data Analysis

The occurrence of *P. javana* determines its position from Mount Ungaran. The distribution pattern was analyzed using the Morisita index (Morisita, 1962). The habitat of *P. javana* is descriptively described based on this data and analyzed with environmental factors using PAST3 (Paleontological Statistics).



**Figure 1.** The occurrence of *P. javana* at Mount Ungaran

## RESULTS AND DISCUSSION

### Structure Population

The results showed that *P. javana* was only found at 5 from 13 locations (Figure 1). The total population of *P. javana* on Mount Ungaran was 213 individuals (Table 2). This number is less than the population of *P. javana* found on Mount Slamet (Zulkarnaen et al., 2019). The limited occurrences indicate that *P. javana* requires specific habitat conditions to support the success

of growing and spreading. *P. javana* is more commonly found on the southern side of Mount Ungaran (Figure 1) and is also supported by the highest number of individuals found on this site, particularly Bantir and Klenting Kuning (Table 2).

On Mount Ungaran, *P. javana* was found at 1.000-1.300 m asl and similar to other studies about the natural elevational range of this species (Witono et al., 2002; Zulkarnaen et al., 2019; Zulkarnaen et al., 2020). However, Alandana et al.

**Table 2.** The discovery of *P. javana* at Mount Ungaran

Location	<i>P. javana</i> population	Stage			Total
		Mature	Juvenile	Seedlings	
Indrokilo forest	-	-	-	-	-
Semirang forest	-	-	-	-	-
Lawe Kalisidi forest	-	-	-	-	-
Medini Forest	√	1	-	-	1
Gebugan Nature Reserve	-	-	-	-	-
Gonoharjo forest	-	-	-	-	-
Klenting kuning forest	√	8	-	99	107
Bantir forest	√	4	3	86	93
Gedong Songo forest	-	-	-	-	-
Nirwana forest	√	5	5	-	10
Merangan hill forest	√	-	1	1	2
Kali kesek forest	-	-	-	-	-
Umbul Sidomukti forest	-	-	-	-	-
<b>TOTAL</b>		18	9	186	213

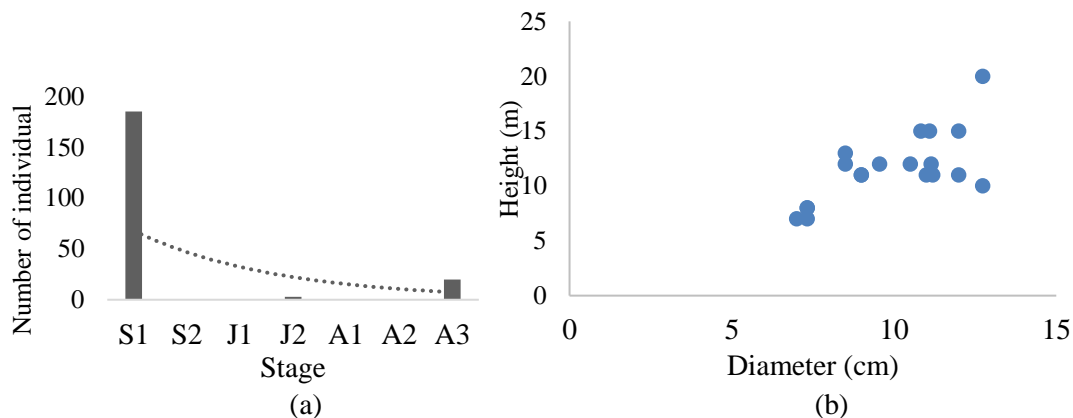
(2015) reported that a population of *P. javana* in Mount Gede Pangrango National Park was found at 600-700 m asl. Zulkarnaen et al. (2019) observed that on Mount Slamet, *P. javana* predominantly grows at the southern side. A similar condition was also found on Mount Ungaran, *P. javana* were also at the southern sides.

The population structure of *P. javana* on Mount Ungaran is dominated by the seedlings stage (Figure 2a). The number of individuals in the mature and juvenile stages is lower than the seedlings stage. The diameter classes in the mature stage range are between 7-9 cm with a height of 10-11 m (Figure 2b). However, the number of seedlings-juveniles is very small even though the palm reproduction process is classified annually. The survival rate of this species is relatively low. Therefore, this palm produces as many seeds as possible as a form of adaptation. Zuhri et al. (2019) reported that one individual of *P. javana* can produce 2800 fruits in the mature stage with 5-6 inflorescence.

by conditions of rainfall and other microclimate factors (Zulkarnaen et al. 2019). However, this type of palm is very restricted, only found in the lower montane forest (800-1.700 m asl) in West Java and East Java (Witono et al., 2002). Therefore, this possibility is accidentally by humans, or it could be by animals—the striking red color of the fruit. Naturally, the spread of *P. javana* is usually assisted by forest civets (Zulkarnaen et al., 2020).

The Perhutani has never planted *P. javana* on their forest concession in Mount Ungaran. The community around Mount Ungaran does not use the species as well. *P. javana* on Mount Slamet, while at Mount Halimun-Salak, and Mount Gede Pangrango is used as functional food ingredients such as young shoot vegetables by the local community living around the mountains (Mogea et al., 2002; Alandana et al., 2015; Zulkarnaen et al., 2019; Zulkarnaen et al., 2022). Thus, its existence on this mountain is considered natural.

The results of the morisita index show that the



**Figure 2.** Population structure of *P. javana* in Mount Ungaran. a. Population stage of *P. javana*; b. Diameter classes of *P. javana*

The occurrence of an individual *P. javana* in the middle of a Medini tea plantation is unusual. More studies are required to know how this individual occurs there, while other populations are on natural forests at the southern sides. This individual was found on a roadside ravine in the middle of the Medini tea plantation. The Medini tea plantation has an area of 386.82 ha with an elevation range of 950 – 1.775 m asl (Wachjar & Supriadi, 2015). Therefore, based on the altitude of the Medini tea plantation, *P. javana* is still suitable to be found (Witono et al., 2002). This location has relatively high rainfall, about 4.060 mm/year (Archive of Medini Plantation Office, 2011). Based on the study of the population of *P. javana* in the montane forest in Java, it is known that the distribution of this palm is not influenced

distribution pattern of *P. javana* in Mount Ungaran is clumped distributed ( $I_d=0.52$ ). This result is similar to the dispersion pattern of this species in Mount Gede Pangrango and Mount Slamet that resemble clump distribution (Wihermanto, 2004; Zulkarnaen et al., 2020). Generally, the distribution pattern of plant species tends to be clumped because plants reproduce by producing seeds that fall close parent (Wahyuni et al., 2017). However, uniform patterns of dispersion are generally the result of interactions between individuals, such as competition (Walker, 2011). In the case of *P. javana*, competition is very likely due to the invasion of alien invasive species. Based on our observation in Mount Ungaran, coffee plants, most likely *Coffea canephora* (Rubiaceae), dominate the forest's understorey.

The dominancy of this species hinders the regeneration of *P. javana*, that might indirectly shape the dispersion pattern.

**Habitat Requirement**

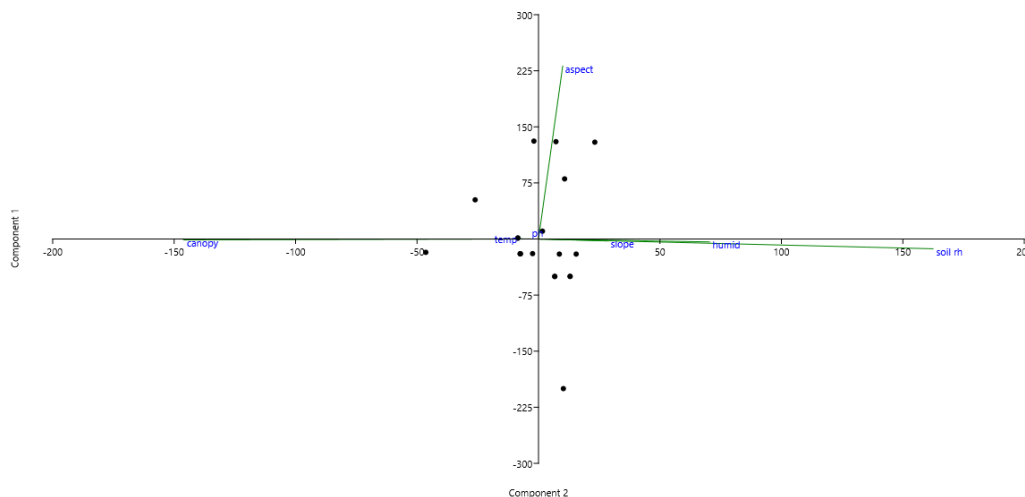
The growth of a plant, in general, has a certain tendency towards a suitable habitat to grow (abiotic and biotic factors) to support its survival in its natural habitat (Yudaputra et al., 2022; Latifah et al., 2020; Zulkarnaen et al., 2017). In addition, sometimes, plants also influence the presence of other plants (plant associations) (Helmanto et al., 2020). Latifah et al. (2020) also added that there are special strategies that plants usually do, germination strategies and increasing seedling survival. This condition also occurs in palms. In general, palms have relatively easy growing requirements, especially supported by year-round reproduction and fast germination (Zuhri et al., 2019).

population is dominant on the southern sides (Zuhri et al. 2020). The environmental factors recorded in the *P. javana* habitat are an average temperature of 18.8 °C, soil humidity 79.45 RH, and air humidity 74.4 RH (Table 3). Therefore, there is a special preference that this palm growth prefers moist locations. Table 3 also provides information that the level of slope that becomes the distribution of *P. javana* is in the slope range from 35°-70°. The slope is steep to the very steep slope. This condition may be one of the causes for the distribution of *P. javana* seeds not being around mature palms because they are carried away by water flows or fall down the slopes.

Principal component analysis (PCA) revealed that the aspect factor had a dominant role in the presence of *P. javana* (Figure 3). Previously it was known that most *P. javana* is in aspect near 200° (Southern). The southern aspect is certainly

**Table 3.** Environmental factors in *P. javana* population

Variable	Min	Max	Mean	Std.error	Stand.dev
Slope	35	70	44.9	1.83	8.17
Aspect	0	330	199.5	17.21	76.95
Ph	6.5	7.8	7	0.10	0.46
Soil_rh	45	90	79.45	2.93	13.10
Temp	18	20	18.8	0.20	0.89
Humid	28	81	74.4	2.54	11.37
Canopy cover	30	78	41.4	2.67	11.93

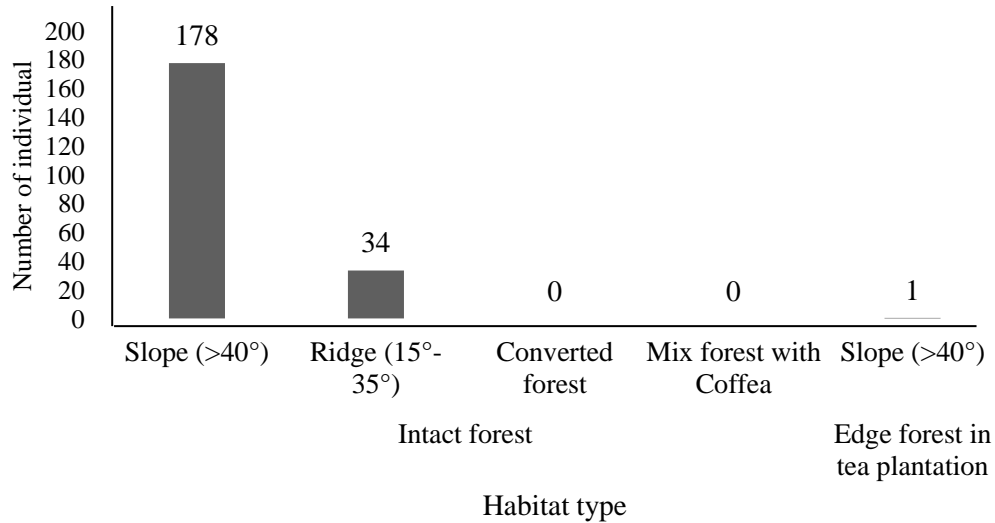


**Figure 3.** Principal component analysis between environmental factor and occurrence of *P. javana*

The occurrence of *P. javana* in Mount Ungaran is relatively similar to other studies. The majority are found only on the southern side. The condition was also similar in Mount Gede Pangrango National Park (Selabintana), where the *P. javana*

strongly correlated with a stable and humid microclimate because the intensity of sunlight on the southern sides in the morning and afternoon has no effect on the microclimate, so the southern sides tend to be more humid than other sides that





**Figure 4.** Population survivorship for *P. javana* at different habitat type



**Figure 5.** a. Mature individual; b. Seedlings of *P. javana*; c. Seeds of *P. javana* scattered by civet

are directly exposed to sunlight. The theory is that high sunlight will reduce high humidity (Gunarsih, 2016). Humidity levels are also known to significantly influence the presence of *P. javana* on the southern sides of Mount Slamet (Zulkarnaen et al., 2019).

In another study of palm habitat, Yudaputra et al. (2022) that suitable habitat for the endemic population of the *Pinanga arinasae* palm in Bali is influenced by several variables, including litter

depth and elevation canopy openness and slope. *Pinanga arinasae* growth tends to be more in flat locations, although some populations are also found on steep slopes.

Meanwhile, the distribution of *P. javana* seems to prefer locations with steep to very steep slopes. It is caused by the majority of the population of *P. javana* in Mount Ungaran located in areas with steep slopes (Figure 4). Figure 4 also provides information that a small population is growing on

the ridges. The locations of the habitat distribution of the *P. javana* population on Mount Ungaran also have similarities with the *P. javana* population found on Mount Slamet (Zulkarnaen et al., 2019). Zulkarnaen et al. (2019) provide information that the total population of *P. javana* found is on very steep slopes ( $>45^\circ$ ). However, it is also possible that the spread in the slopes is a form of defense from *P. javana*, which is threatened by other factors when in sloping areas, such as humans and other predators like wild boar. This animal is known to be one of the predators of *P. javana* on Mount Slamet (Zulkarnaen et al., 2019).

Figure 5 generally provides an overview of the growth and distribution of *P. javana* on Mount Ungaran. Figure 5a showed that the majority of mature individuals grew up in open and shaded areas. Therefore, from the point of view of where it grows, there are no problems in open or shaded conditions. However, the development of the survival rate from the seedling–mature stage is still low. However, many seedlings were found in several locations close to the mature palm (Figure 5b). The number of juvenile stages was not matched as well. There are abundant seedlings which indicate that reproduction occurs annually.

Furthermore, Figure 5c illustrates one of the pieces of evidence of *P. javana* seed dispersal assisted by forest civet as its dispersal agent. Based on the explanation above, the growth cycle of *P. javana* is no problem. The threat of population reduction is more natural, such as landslides, because most of the population is on slopes. Therefore, even though the population is large but its habitat is very vulnerable, the conservation status of this palm can increase in the coming years. However, to know the distribution area and habitat of *P. javana*, a detailed population assessment is needed throughout Java.

### Conservation Implications

Indonesia has 959 plants that are included in threatened species (IUCN, 2021). This number is predicted to continue increasing with conservation threats, such as land conversion, deforestation, land degradation, and others. These threats also threaten Indonesian palm species, where Indonesia has a 20% contribution to world palm diversity (Widyatmoko, 2019). Widyatmoko (2019) also revealed that around 53% of Indonesian palms are endemic.

The existence of *P. javana*, which is recorded as an endemic Java palm, should be one of the concerns in future conservation activities.

According to fields data and herbarium records, the predicted distribution of *P. javana* may also be widespread throughout the Java mountain forests. However, a re-assessment is needed to determine the existence of this palm. From the assessments that have been carried out in several locations, this palm growth trend shows a declining population trend for survival to mature individuals. Not to mention its preferred habitat on the slopes, which indicates a higher potential threat due to natural factors.

The growth of *P. javana* is necessary to analyze the decrease from seedlings to mature. Because as is known that this palm always produces fruit is annual. The process of successful germination is also very easy. The total number of seedlings population is very abundant, however, in contrast to the total population of mature individuals. In addition, the conservation efforts of *P. javana* can also be replanted in locations where this species is not known. This action aims to maintain the availability of the *P. javana* population in the wild. For example, areas on the edges of the forest or in other open areas in the forest.

In addition, *P. javana* has been successfully grown as a collection plant in two ex-situ conservation areas: Cibodas Botanic Gardens and Baturraden Botanic Gardens (Sujarwo et al., 2019; Irawan et al., 2015; Zulkarnaen et al., 2021). Nevertheless, the source of *P. javana* collections is limited only around the botanic garden location. It has not been enriched from other locations that have recorded populations of *P. javana*. Therefore, conservation efforts to conserve this palm from montane forest others are still needed.

### CONCLUSION

The population of *P. javana* on Mount Ungaran is new information for its distribution in Java. The population structure of *P. javana* was dominated by the seedlings stage. The majority of the locations found in *P. javana* are located in the Klenting Kuning forest and Bantir forest (most population). Some individuals are also found in the Medini forest, Nirwana forest, and Merangan hill forest. The habitat requirement of *P. javana* in Mount Ungaran is mainly found on the intact forest with slopes ( $>40^\circ$ ) (most population) and ridge ( $15^\circ$ -  $35^\circ$ ) and mainly distributed in the aspect near  $200^\circ$  (Southern side) of the Mount Ungaran. In addition, other environmental factors that support the existence of this population include air humidity and soil humidity.

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