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Distribution Pattern of Pasang Species *(Quercus sundaica* Blume*)* in Mount Slamet Forest, East Banyumas Forest Management Unit

(Pola Distribusi Jenis Pasang (Quercus sundaica Blume) di Hutan Gunung Slamet, KPH Banyumas Timur)

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RESEARCH ARTICLE

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ABSTRACT

Quercus sundaica (*Q. sundaica*), commonly known as Pasang, is a Fagaceae family member with a significant ecological and economic contribution to Indonesia. This research aimed to examine the abundance, distribution pattern, and physical growth environment of *Q. sundaica*. The data collection occurred in KRB (Baturraden Botanical Garden) and P7 (Pancuran 7) in the montane and sub-montane zones. The data analysis included vegetation and soil analysis. The KRB track in the montane zone had the highest Importance Value Index (IVI) with a higher density than the KP7 track.

INTISARI

Pasang (Quercus sundaica) merupakan salah satu jenis dari famili Fagaceae yang memiliki nilai ekologi dan ekonomi penting di Indonesia. Penelitian dilakukan untuk mengkaji kelimpahan, pola penyebaran, dan lingkungan fisik pertumbuhan Q. sundaica. Pengambilan data dilakukan jalur KRB (Kebun Raya Baturraden) dan Jalur P7 (Pancuran 7) pada zona sub-montana dan montana. Analisis data yang digunakan meliputi analisis vegetasi dan tanah. Hasil penelitian menunjukkan bahwa jenis Q. sundaica pada Jalur KRB zona montana mempunyai nilai INP tertinggi dan memiliki kerapatan yang lebih tinggi dibandingkan dengan Jalur P7.

Introduction

Indonesia's forests are varied and rich in resources. One of the Indonesian forest ecosystems is the montane forest. Mount Slamet lies on the border of Brebes, Banyumas, Purbalingga, Tegal, and Pemalang Regencies, Central Java Province. This montane forest consists of sub-montane and montane zones. The sub-montane zone covers 1000-1500 meters above sea level (masl), while the montane covers 1500-2400 masl. Mount Slamet has protected forests with high biodiversity and complex vegetation structure. The vegetation structure and diversity provide an overview of the spatial arrangement of the ecosystem components, life forms, stratification, and vegetation cover (Gunawan et al. 2011). *Q. sundaica* timbers are often used as raw materials for furniture, veneer, and carts due to their beautiful whitish-brown to reddish colors and unique grain. Siamangs (*Syphalangus syndactylus*) often use the *Q. sundaica* trees as a place to play and rest (Permatasari *et al.* 2017). *Q. sundaica* plants dominate the lower mountain forest areas (Sadili 2011), growing at 50-1800 masl altitudes, and are most commonly found at 1600 masl.

The regeneration process is crucial in the forest ecosystem to continue forest succession. Natural regeneration occurs naturally from seedlings, saplings, poles, and trees. It plays a crucial role in shaping the forest stand structure and species composition (Damayanti et al. 2017). The quercus species fall into NT (Near Threatened) of the IUCN classification. Identifying required environmental conditions and protecting its natural habitat could support the propagation and growth of *Q. sundaica.* This research aimed to examine the abundance and distribution patterns and evaluate the physical environment to facilitate growth of *Q. Sundaica.*

Materials and Methods

Materials

This research used trees and regeneration of *Q. sundaica* and other species in the observation plots and their physical environmental factors. This research used various tools, including a map of the Gunung Slamet area, a topographic map, altimeters, raffia rope, a clinometer, a compass, machetes,

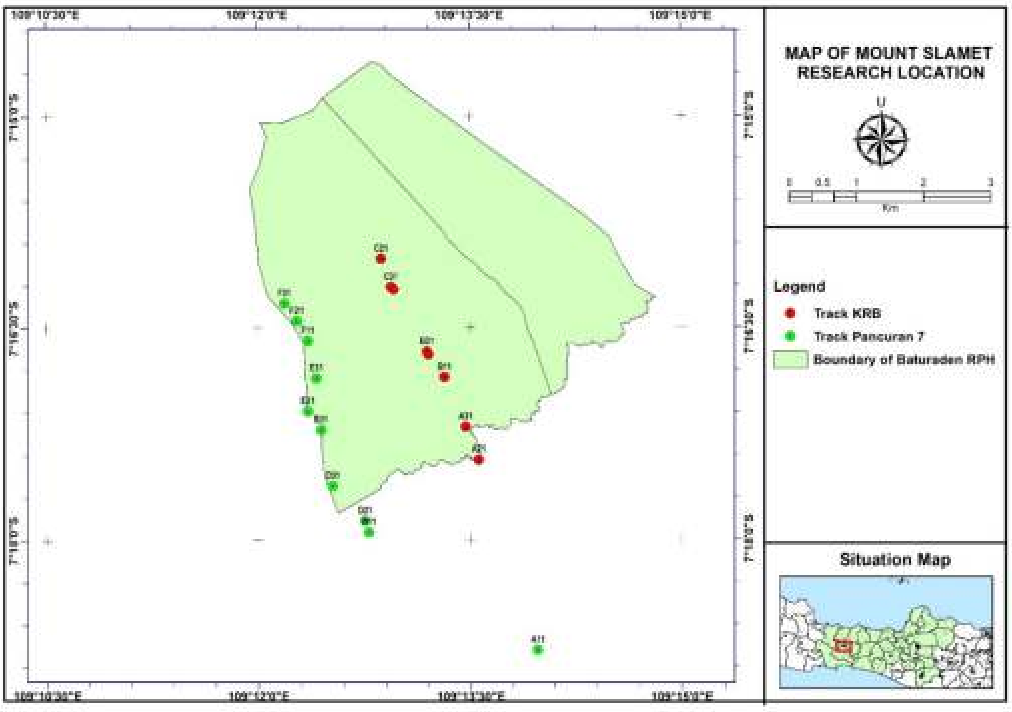

Figure 1. Map of the research area and the location of the observation plots on Mount Slamet

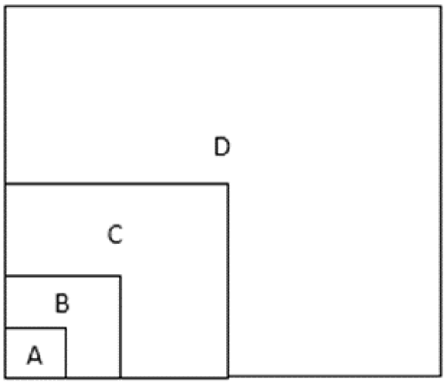

Figure 2. Sample plots of vegetation analysis in the field: (A) seedlings (2 m x 2 m), (B) saplings (5 m x 5 m) poles (10 m x 10 m), (D) trees (30 m x 30 m)

measuring tapes, GPS (Global Positioning System), diameter tapes, writing tools, a hypsometer, cameras, tally sheets, labels, dry-wet thermometers, and clear trash bags.

Sampling

The sample selection used stratified sampling with a random start. The strata consisted of the elevation of montane forest formation (sub-montane and montane), slope, and the *Q. Sundaica* presence. Data collection took place on two tracks with nine observation plots per track. The first track was in the Baturraden Botanical Garden (KRB track), consisting of five observation plots in sub-montane (A11, A21, A31, B11, B21) and four in montane (B31, C11, C21, C31) zones. The second track was in Pancuran Pitu (P7 track), consisting of five observation plots in sub-montane (D11, D21, D31, E11, E21) and four in montane (E31, F11, F21, F31) zones (Figure 1). This research used nested quadrat or nested square observation plots. The size of the observation plots for seedlings, saplings, poles, and trees consecutively was 2 m x 2 m, 5 m x 5 m, 10 m x 10 m, and 30 m x 30 m (Figure 2).

Data Collection

The data collection included vegetation, physical environment, and soil properties. The vegetation data comprised each plot's number of seedlings, saplings, poles, and trees. The data collection for poles and trees in each plot also included the local names, diameter, total height (TH), and bole height (BH). The description of vertical and horizontal stand structures used diameter and height data. The vertical stand structure consisted of five classes based on canopy strata, namely stratum E (height 0-2 m), stratum D (height 3-5 m), stratum C (height 6-20 m), stratum B (height 21-30 m), and stratum A (>30 m). The horizontal stand structure consisted of six diameter classes, namely 10-19 cm, 20-29 cm, 30-39 cm, 50-59 cm, and >60 cm (Kusmana 2099).

The physical environmental properties data included temperature, humidity, and topography (elevation, slope, and aspect). Environmental factors such as climate, soil, and topography could affect the presence of plant species in a particular location (Istomo & Sari 2019). Daily temperature and humidity measurements were collected twice a day, in the morning from 06.00-09.00 WIB and in the afternoon from 11.00-14.00 WIB, for one month starting from January 17th 2022. Temperature measurements used a dry-wet thermometer under the shade, while the relative humidity calculation used the available dry-wet formula and tables. The elevation measurements used the value indicated on a Garmin GPS. The slope measurement used a clinometer, and the aspect used a compass.

Disturbed soil sample collection occurred in each observation plot (18 plots). The soil sample collection used a small shovel to reach the soil depth of 20-40 cm at three points within the plot (approximately 200 gr of soil from each point) and mixed it into one soil sample for each observation plot (18 soil samples). The soil samples analysis included chemical properties, such as pH, Cation Exchange Capacity (CEC), P-potential phosphorus, and K-potential potassium.

Analysis

Importance Value Index (IVI)

The Importance Value Index (IVI) was calculated using the following formulas (Mueller-Dombois and Ellenberg 1974).

$$\text{Density} = \frac{\text{Number of Individuals}}{\text{Sample Area}}$$

$$\text{Relative Density (RD)(\%)} = \frac{\text{Density of a species}}{\text{Density of total species}} \times 100\%$$

$$\text{Frequency} = \frac{\text{Number of plots where a species is found}}{\text{Total number of plots}}$$

$$\text{Relative Frequency (RF)(\%)} = \frac{\text{Frequency of a Species}}{\text{Frequency of total species}} \times 100\%$$

$$\text{Dominance (D)} = \frac{\text{Basal area of aspecies}}{\text{Total sample plot area}} \times 100\%$$

$$\text{Relative Dominance (DR)} = \frac{\text{Dominance of a species}}{\text{Dominance of all species}} \times 100\%$$

IVI (seedlings and saplings) = RD + RF

IVI (poles and trees) = RD + RF + DR

Morisita Index of Dispersion ($I\delta$)

The Morisita Index of Dispersion (Ip) became one of the best indicators for measuring dispersion. Its calculation used the equation below (Michael 1994).

$$I\delta = q \times \frac{\sum Xi\,(Xi-1)}{T\,(T-1)}$$

where: $I\delta$ = Morisita's degree of dispersion; Xi = number of individuals per plot; q = number of observation plots; T = total number of individuals in all plots. If $I\delta = 0$, then the pattern of dispersion is random; $I\delta < 0$, then the pattern of dispersion is uniform; $I\delta > 0$, then the pattern of dispersion is clumped.

Results and Discussions

Abundance, Importance Value Index (IVI), Stand Structure, and Distribution Pattern

The number of seedlings of all species was lower than other growth levels, while the number of trees was the highest in the KRB track and P7 track (Table 1). This result was inconsistent with Kusmana and Susanti (2015), who suggested that the seedlings were dominant. The number of species decreased from sub-montane to montane in the KRB track and P7 track, except for the number of pole and tree species. As the altitude increased, the number of species decreased (Rozak et al. 2016).

The *Q. sundaica* trees (Figure 1) could grow well in the sub-montane and montane zones of KRB and P7 tracks (Table 2). In the KRB track, the sub-montane zone had a higher *Q. sundaica* tree density than the montane zone, while in the P7 track, the sub-montane zone had a lower *Q. sundaica* tree density than the montane zone. In general, the P7 track had a higher *Q. sundaica* tree density than the KRB track.

Seedlings had the highest density for other species compared to saplings, poles, and trees. This result was similar to tropical natural forests

Table 1. Number of species at each growth stage in KRB and P7 tracks

Growth Stages	Number of Species			
	KRB Track		P7 Track	
	Sub-montane	Montane	Sub-montane	Montane
Understory plants	12	15	18	14
Seedling	8	1	9	4
Sapling	13	8	18	13
Pole	4	8	6	6
Tree	19	25	16	17

Table 2. The density of *Q. sundaica* and other species in KRB and P7 Tracks

Growth Stages	Species	Density (Individu/ha)			
		KRB Track		P7 Track	
		Sub-montane	Montane	Sub-montane	Montane
Seedling	***Q. sundaica***	0	0	0	0
	Other Species	8500	1875	12000	11250
Sapling	***Q. sundaica***	0	0	0	100
	Other Species	2640	4400	3200	2700
Pole	***Q. sundaica***	0	0	0	0
	Other Species	160	400	320	175
Tree	***Q. sundaica***	13.32	3.33	4.44	16.66
	Other Species	124.44	236.11	144.44	141.67

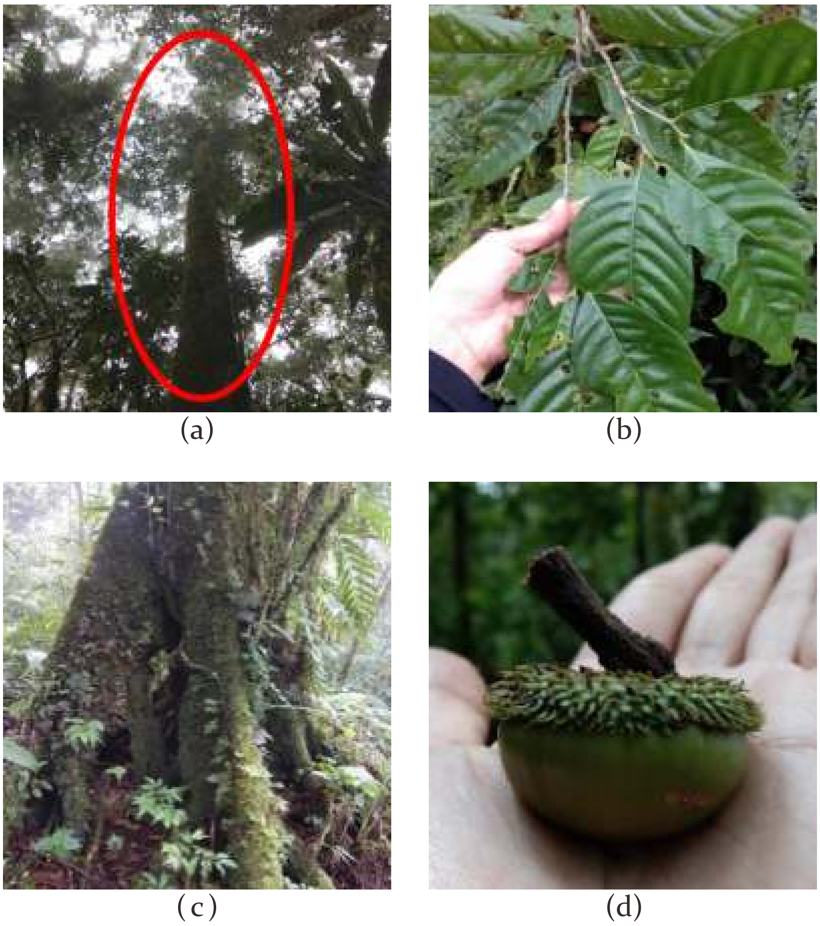

Figure 3. The Q. sundaica tree (a), leaves (b), roots (c), and fruit (d)

(Atmandhini 2008). However, the observation found no seedlings, saplings, or poles in all observation plots (Table 2). The regeneration ability of forest trees depends on their success in completing the entire reproduction cycle, from the formation of flower buds to the development of seedlings (Khairilkasdi et al. 2017). Primates, such as the *lutung* (*Trachypithecus auratus)*, Javan gibbon (*Hylobates moloch*), and Javan surili (*Presbytis Frederica*), often ate the leaves and fruits, which enabled them to become seed dispersal agents (LIPI 2012). However, if these primates did not facilitate seed dispersal, the seeds would fall under the same tree's shade, disturbing the natural dispersion process because natural regeneration tended to occur in the exact location (Irwanto 2006). Besides, seed damage became a crucial factor affecting the scarcity of *Q. sundaica* natural regeneration. The species produced edible seeds known as chestnuts, becoming an essential diet for fauna. The observation found a substantial amount of damaged chestnut on the forest floor, gnawed by fauna, hindering the natural regeneration of *Q. sundaica*.

The expression of species dominance in the forest stand included basal area, volume, and Importance Value Index (IVI). The IVI of species was used to show the role of a species in its community. Species with the highest IVI differed for KRB and P7 tracks, within the tracks (sub-montane and montane) and between seedlings, saplings, poles, and trees (Table 3). The presence of a plant in an area indicates its adaptation ability to the habitat and tolerance to the environment (Soegianto 1994), and the dominant species had adapted better to their environment than other species.

The *Q. sundaica* tree species had the highest IVI in the sub-montane zone of the KRB track and the second-highest value in the montane zone of the KP7 track, indicating that the *Q. sundaica* was more common at the elevation of 1000-1500 masl than 1500-2000 masl. The Fagaceae family was dominant in Indonesia at elevations below 1300 masl and less common as altitude increased (Purwaningsih & Polosakan 2016). The dominance of a plant in one location or growth stage also depended on the

Table 3. The IVI of species seedlings, saplings, poles, and trees at sub-montane and montane zones of the KRB and P7 tracks

Growth Stages	Elevation	KRB Track		P7 Track	
		Species	IVI	Species	IVI
Seedling	Sub-montane	*Ficus ribes*	43.69	*Duranta erecta*	55.68
		Plectronia dydina	37.82	*Eugenia microcyma*	48.11
		Mesua ferrea, Helicia javanica		*Leucaena leucocephala*	21.59
		Blume, Erioglossum rubiginosum	26.05	***Q. sundaica***	0
		Q. sundaica	0		
	Montane	*Rauvolfia tetraphylla*	200.00	*Ficus fistulosa*	132.22
		Q. sundaica	0	*Plectronia dydina*	36.67
		-	-	*Morinda citrifolia*	31.11
		-	-	***Q. sundaica***	0
Sapling	Sub montane	*Astronia* sp,	43.03	*Acronychia pedunmculata*	27.50
		Flacourtia rukam	25.46	*Symplocos fasciculata*	20
		Ficus ribes	22.42	*Machilus rimosa, Eugenia microcyma*	17.50
		Q. sundaica	0	***Q. sundaica***	0
	Montane	*Vaccinium varingiaefolium*	55.46	*Saurauia bracteosa*	25.55
		Mesua ferrea	26.82	*Symplocos fasciculata*	21.98
		Turpinia sphaeocarpa	25.91	*Coffea canephora, Plectronia dydina*	18.41
		Q. sundaica	0	***Q. sundaica***	**11.26**
Pole	Sub montane	*Antidesma tetandrum*	176.83	*Antidesma tetandrum*	141.85
		Mesua spp,	45.72	*Turpinia sphaeocarpa*	82.49
		Litsea cubeba	42.42	*Nauclea grandifolia*	28.31
		Q. sundaica	0	***Q. sundaica***	0
	Montane	*Schefflera actinodaphnephylla*	88.83	*Schefflera actinodaphnephylla*	83.75
		Turpinia sphaeocarpa	59.02	*Litsea cubeba*	45.99
		Alseodaphne umbelliflora	35.87	*Turpinia sphaeocarpa*	45.55
		Q. sundaica	0	***Q. sundaica***	0
Tree	Sub montane	***Q. sundaica***	**61,99**	*Agathis dammara*	55.49
		Litsea cubeba	35.13	*Antidesma tetandrum*	34.72
		Actinodaphne glomerata	35.81	*Litsea cubeba*	32.76
		Castanopsis argantea	19.23	***Q. sundaica***	27.22
	Montane	*Actinodaphne glomerata*	48.34	***Q. sundaica***	48.54
		Schefflera actinodaphnephylla	35.32	*Cinnamomum porectum*	30.11
		Alseodaphne umbelliflora	22.2	*Glochidion kollmanniamum*	26.73
		Q. sundaica	**97.72**	*Aporosa arborescens*	22.100

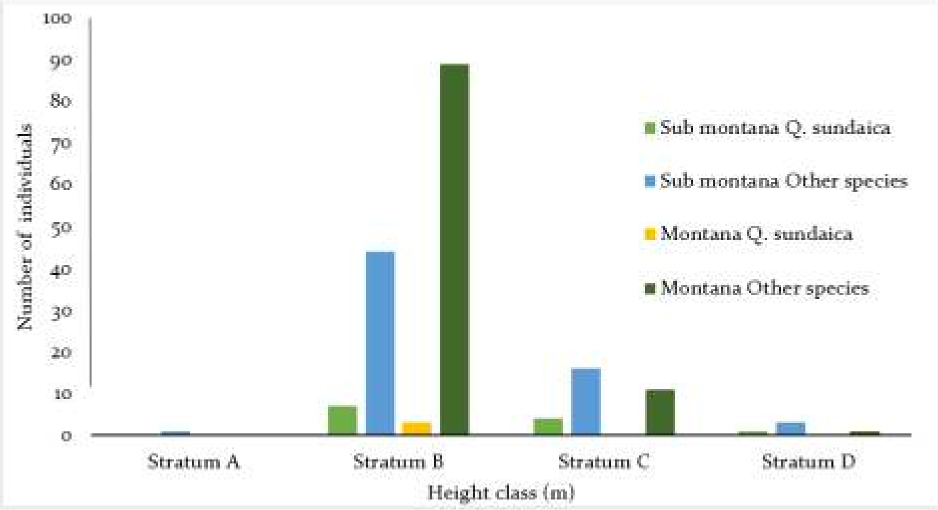

Figure 4. Vertical distribution (height class) of species in the KRB track

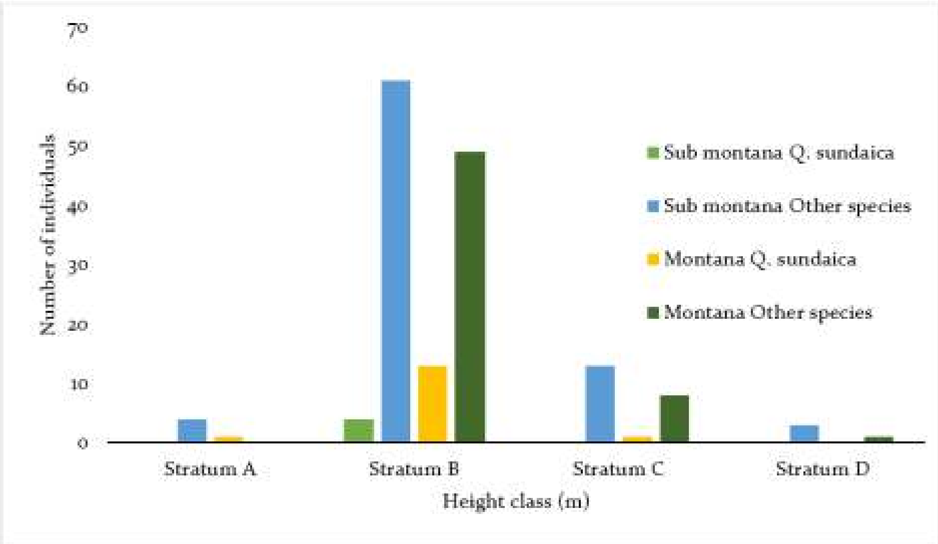

Figure 5. Vertical distribution (height class) of species in the P7 track

decrease in the number of individuals of a species or the loss of species in the community (Sigiro 2013). Moreover, climate variables, energy availability, ecosystem productivity, historical and evolutionary processes, and limitations of distribution area contributed to *Q. sundaica* presence (Suwandi 2014).

The stand structure described the forest stand shape vertically and horizontally. The vertical stand structure referred to the relationship between tree height classes and the number of individuals (Figures 4 and 5). The vertical distribution indicated that in the KRB and the P7 tracks, all species, including *Q. sundaica,* were in the height class of 21-30 m (stratum B). The number of trees decreased as the height increased. Most species need more time to reach strata A and B due to competition for groundwater, nutrients, or sunlight (Istomo & Sari 2019).

Forests dominated by stratum C or D tended to have more natural regeneration (saplings and poles) than mature trees and could ensure the sustainability of future regeneration (Susanti 2014). The saplings and poles could serve as the subsequent forest regeneration process. The vertical structure of the forest stand describes the relationship of all plant species in a stand (Putri et al. 2019), including dominant trees, stressed trees, and forest floor (Indriyanto 2017).

The horizontal structure indicated the

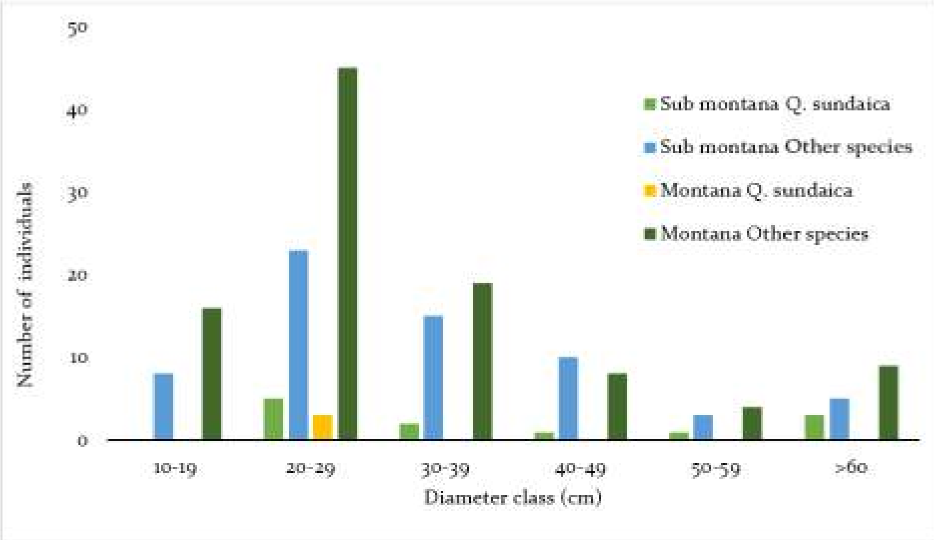

Figure 6. Horizontal distribution (diameter class) of species in the KRB line

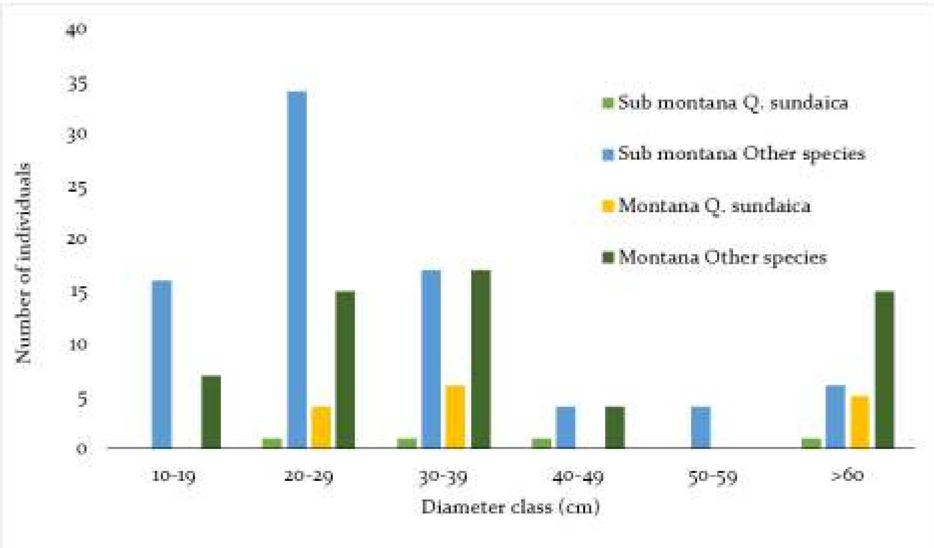

Figure 7. Horizontal distribution (diameter class) of species in the KP7 track

relationship between diameter classes and the number of individuals (Figures 6 and 7) tree density per hectare (Marsudi et al. 2018). In the KRB track, *Q. sundaica* had the highest number of individuals in the 20-29 cm diameter class, and the lowest was in the 50-59 cm diameter class. Within the 20-29 cm diameter class, the sub-montane zone had more individuals than the montane zone (Figure 6). In the P7 track, *Q. sundaica* had the highest number of individuals in the 30-39 cm diameter class, and the lowest was in the 50-59 cm diameter class. Within the 30-39 cm diameter class, the montane zone had more individuals than the sub-montane zone (Figure 7).

For other species, the KRB track had the highest number of trees in the 20-29 cm diameter class and the lowest in the 50-59 cm diameter class. Within the 20-29 cm diameter class, the sub-montane zone had more individuals than the montane zone (Figure 6). The P7 track had the highest number of trees in the 30-39 cm diameter class and the lowest in the 50-59 cm diameter class. Within the 30-39 cm diameter class, the montane zone had more individuals than the sub-montane zone (Figure 7). The natural forests in Mount Slamet had various diameter classes, and the larger the tree diameter, the fewer the number of trees Oladoye et al. (2014). Competition among species for nutrients,

Table 4. Morishita Index of *Q. sundaica*

Track	Zone	Morisita Index	Category
KRB	Sub-montane	0.01	Clumped
	Montane	0.28	
P7	Sub-montane	0.05	
	Montane	0.45	

sunlight, minerals, and self-defense against pests and diseases continued in the whole ecosystem, leading to natural selection and causing a reduction in the number of individuals of particular species (Kusmana & Susanti 2015).

The Morisita index determines the distribution pattern of a tree species. The Morisita index value for *Q. sundaica* species was more than zero for the sub-montane and montane zones of the KRB and P7 tracks (Table 5), indicating that the species had clumped distribution. Clumped species distribution indicated a favorable habitat for particular species (Rani 2003). In the research location, the clumped species distribution resulted from the seeds falling around the parent trees. These seeds would germinate and develop seedlings when the environment could support natural regeneration. The seeds or fruits of species with a clumped distribution pattern generally had a relatively small size, enabling them to spread within a sufficient radius (Arrijani 2008).

Environmental Physical Factors

Temperature, humidity, slope, and aspect

The environmental conditions determined the distribution pattern of a forest stand. Environmental conditions in montane forests, such as temperature, humidity, elevation, and topography, affect the presence, existence, and distribution of various types of plants (Suwandi 2014). The *Q. sundaica* species commonly grew at 1600 masl (montane zone) elevation. However, it could also grow well at elevations ranging from 50-1800 meters above sea level or in the lower montane forest (Sadili 2011). Table 6 indicated that the average temperature was inversely proportional to the average relative humidity because of the sunlight intensity (Ibadurrohman 2016). The slope classification by Syah & Hariyanto (2013) showed that the KRB track had an average slope of 46.543% (very steep), while the P7 track had an average slope of 47.921% (very steep). Both tracks were dominated by the south aspects, indicating that the plants mostly

Table 6. Temperature, humidity, slope, and aspect at the research site

Track	Plot	Temperature (°C)	Average temperature (°C)	Humidity (%)	Average humidity (%)	Slope (%)	Aspect
KRB	A11	22.5	20.0	92	78.3	30	Southeast
	A21	21		75		30	South
	A31	21		83		45.6	Northeast
	B11	20		75		47.1	East
	B21	19		82		54	North
	B31	18.5		74		58.1	Northeast
	C11	19.5		75		54.2	South
	C21	19		74		51.7	South
	C31	20		75		48.2	Southeast
P7	D11	21	18.6	83	89.1	32	South
	D21	22		84		43.9	West
	D31	21		91		46.20	Northeast
	E11	20		91		49.93	Southeast
	E21	19		91		43.73	South
	E31	19		91		45	South
	F11	17		91		59.10	Southeast
	F21	17		91		57.83	South
	F31	11		89		52.57	South

Table 7. The results of soil analysis of the research site

Track	Zone	Parameter				
		pH		P205 Potential	K205 Potential	CEC
		H_2O	*N* Kcl			
KRB	Sub-montane	5.67	4.56	46.29	24.52	18.70
	Montane	5.92	4.70	50.39	36.17	19.34
P7	Sub-montane	5.63	4.63	45.72	23.46	22.01
	Montane	6.14	4.82	49.14	29.38	16.40

received sunlight from the south. On a micro-scale, an aspect determines the amount of sunlight trees receive (Nurheni & Nurunnajah 2012).

Soil

Site or soil became one of the abiotic factors that affected the growth of living organisms (Oosting 1956). The sub-montane and montane zones of the KRB track and the sub-montane zone of the P7 track had acidic soil, while the montane zone of the P7 track was slightly acidic or close to neutral based on Olson's (1981) pH H2O category. The H2O pH parameter had proportional values to the pH N KCl. Soil pH affects the density of fungi, bacteria, and litter decomposers. The closer the pH to neutral, the faster the decomposition rate (Shi 2013).

P-potential refers to the total amount of P nutrients in the soil. However, the plant roots could absorb only available phosphorus, known as P-available. The soil P-available was lower than P-potential. The same concept applied to the K-potential and K-available (Amelia & Suprayogo 2018). The KRB and P7 tracks had K-potential within 41-60 in the high category based on the Soil Research Center (1983).

Using the same classification, the CEC values of the KRB track ranged from low to moderate, while the KP7 track ranged from low to high. High CEC values were associated with the availability of K nutrients in the soil (Prabowo & Subantoro 2010). The observation found an abundance of litter in the research area that increased soil organic matter (Wezel et al. 2000).

Conclusion

It was confirmed that the research area had sub-montane and montane zones. The montane zone had the most abundant species and dense vegetation. The distribution of height classes was mostly in stratum B, while the distribution of diameter classes was dominantly in the 20-29 cm class. The natural regeneration of *Q. sundaica* was not found in the research location because it needed adequate environmental conditions to support regeneration. The *Q. sundaica* species had a clumped tree distribution pattern in all research tracks, at 1000-1700 masl on the KRB line and 1400-1700 masl on the KP7 line.

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