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Potential feeding plants of Javan Langur (*Trachypithecus auratus*) in the eastern slope of Biru Mountain, Batu City, East Java, Indonesia

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Abstract. *Wardhana HD, Muttaqin T, Aryanti N, Kurniawan I. 2022. Potential feeding plants of Javan Langur (*Trachypithecus auratus*) in the eastern slope of Biru Mountain, Batu City, East Java, Indonesia. Biodiversitas 23: 4216-4222.* The Javan langur (*Trachypithecus auratus*) is an endemic animal in Indonesia and is located on the island of Java. Javan langur is an endemic primate and an officially endangered species. The purpose of this study was to determine the potential of forage plants in the area that will be used as a Javan langur release location so that it becomes one aspect of assessing whether or not it is appropriate for a Javan langur release. This research was conducted in Gunung Biru, Batu City, East Java, Indonesia. The method used is wandering quarter to determine the species composition. The analysis used is vegetation analysis, Morisita distribution index, Shannon-Wiener diversity index, Evenness index, Margalef wealth index, and Sorensen similarity index. The results of this study obtained 45 species of plants from the level of the pole and tree. Some of the dominant species are *Homalanthus giganteus, Quercus sondaicus, Engelhardia spicata,* and *Trema orientalis*. All types of plants found during the study were included in the Javan langur forage plants. The distribution index was clustered at the pole and tree level with a value of 0.081 at the pole and 0.106 at the tree. The diversity index was high at the pole level with a value of 3.272, while the moderate tree level with a value of 2.539. The species richness index showed high at the pole and tree level, with a value of 6.916 at the pole level and 4.461 at the tree level. The evenness of the pole-level vegetation is 0.874 and the tree-level vegetation is 0.789, so it includes a high evenness value. The similarity value between paths below 50% indicates that the similarity is low. Knowing that all species in the area are a source of forage for langurs, it can be said that the forage sources for Javan langurs are very abundant and it can be said that the area is very suitable for the release area of Javan langurs.

Keywords: Distribution, forage, release, wandering, wildlife

INTRODUCTION

Ebony leaf monkey is one of the endemic primates in Indonesia and a species protected by Minister of Environment and Forestry of the Republic of Indonesia No. P.20/MENLHK/SETJEN/KUM.1/6/2018. According to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) it is included in the Appendix II category, wild animals that should not be traded because of their endangered status. Vulnerable status by the International Union for Conservation of Nature and Natural Resources (IUCN) red list due to high human activities, namely hunting, as well as the conversion of forest areas into agricultural land and settlements (Leca et al. 2013; Nijman 2021). The reduction in the presence of tree stands in non-forest areas can impact large mammal species that depend on specific and expansive habitats for locomotion. Javan langurs can still be found in several pockets of habitat in the eastern part of Java Island (Nijman 2013). Primate species are essential components of tropical biodiversity by contributing to forest regeneration and ecosystem health (Estrada et al. 2017). Large mammals are effective seed dispersal agents because they move farther.

As an effort to combat the decline in the population of Javan langurs due to human activities to protect them from illegal trade, confiscations or voluntary handovers are carried out from the community. The animal was then rehabilitated by the ex-situ Javan Langur Center (JLC), part of the Aspinall Foundation Indonesia located in Coban Talun Batu, East Java, before being released into its natural habitat. Before release, it is necessary to find a location based on observations, finding suitable habitat before releasing wild animals is significant because it supports the released animals in the long term. In addition, Lutung is a primate species in groups (Leca et al. 2013; Nijman 2013), so this species needs an area that can cover to find food supplies to meet all its members (Chapman and Teichroeb 2012).

Trachypithecus species show a diet dominated by leaves followed by fruit/seeds, flowers and other types of food (Tran et al. 2019). Javan langur is a species that mostly eats plant parts, namely young leaves, the rest are old leaves, petioles and leaf shoots (Tsuji et al. 2019), but has also been recorded to eat fruit (Aryanti and Azizah 2019; Aryanti et al. 2021). The arboreal lifestyle of langurs has an impact on obtaining food sources, and more species of tree-level plants are found (Fahmi and Bintarawati 2018). The presence of trees and dense canopy serves to support daily activities of eating, resting, socializing and moving (Ayunin et al. 2014; Aryanti and Azizah 2019; Sari et al. 2020). The dense and interconnected canopy allows the langurs to move (Supartono et al. 2016). Therefore, the need for the availability of vegetation is very important for the langurs. Currently, the Javan langur release area around

the JLC location has reached its limit, thus requiring a new place. The JLC plans to release the Javan langur in a natural forest area that is included in the mountainous Tahura R. Soerjo area, namely Mount Biru in the eastern part, which is administratively included in Batu City, East Java. Eating is one of the limiting factors that are very important for the life of the langur (Akbar et al. 2019), the available feed is very sufficient and of good quality, which will be able to support the life and process of growth and reproduction of the langur properly (Zakki et al. 2017). The quality and quantity of wild animal feed sources can affect the presence of wild animals (Arief 2012). However, there is no information regarding the potential availability of natural food plants in that location, feed is one of the essential aspects of improving wildlife viability which is also a limiting factor for animal life (Musyaffa and Santoso 2020). Therefore, information on the potential of forage plants is needed to understand the current conditions of the area that will be used as a rehabilitation area for Javan langurs released from the JLC. It is the basis for an appropriate and effective area management plan to ensure species diversity, especially the conservation of Javan langurs in East Java, Indonesia.

MATERIALS AND METHODS

Study area

This research activity was carried out in December 2020 - January 2021, in the Grand Forest Park (Tahura) R. Soerjo area, especially in the protected forest area on the eastern slopes of Gunung Biru, Batu City, East Java, Indonesia. Under Government Regulation of the Republic of Indonesia No. 28 of 2011, the function of Tahura for collect natural or non-natural plants and/or animal species that are not invasive and utilized for research, science, education, cultivation, culture, tourism and recreation. The location and path of observation can be seen in Figure 1.

Procedures

Collecting data

Collecting data in the field using the method of analysis of vegetation without plots, used to wandering quarter method. Using the wandering quarter method, the vegetation structure is analyzed only at the tree and pole level. This selection is based on the Javan langur in carrying out their daily activities, most of which are carried out on the tree and pole strata. Wandering quarter method can increase the accuracy or precision of density and be able to study the distribution pattern of vegetation (Zhu et al. 2014).

Based on the visual survey (accessibility and topography) used to determine the location of the transect by purposive sampling. However, based on the visual survey did not have enough to determine the release area. But it was necessary to know the potential of forage plants through vegetation analysis. The number of transects made the protected forest area on the eastern slope of Gunung Biru was 3 lines. Each transect has a length of 1000 meters for the vegetation analysis. On each transect, there is a distance between observation points of 25 meters so that there are 40 observation points. The starting point of each transect was 50 meters, perpendicular to and away from the border of the community's plantation area.

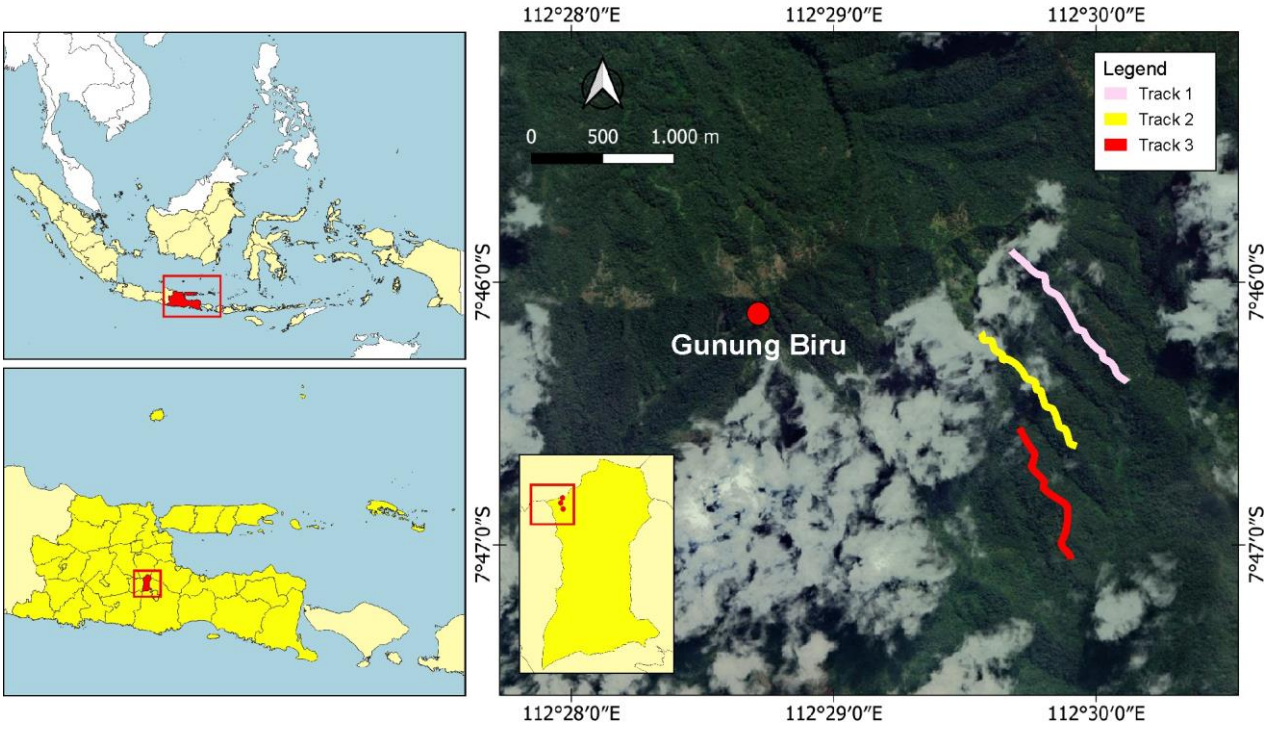

Figure 1. Location of Gunung Biru, Batu City, East Java, Indonesia and the sampling sites of *Trachypithecus auratus*

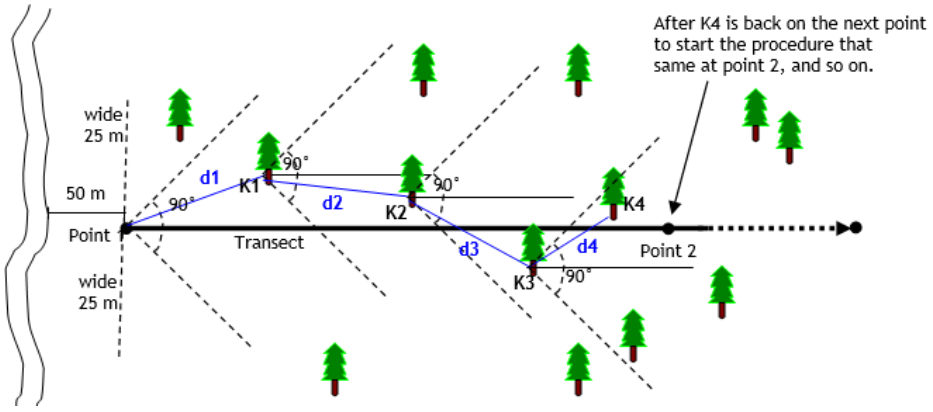

Figure 2. Design transect of wandering quarter method on Gunung Biru, Batu City, East Java, Indonesia

The wandering quarter method begins by making a transect line and establishing a starting point for the measurement, then identification along the transect with the right and left boundaries of the transect, each 25 meters wide. Then by using a compass, the first point as the first quadrant with made an angle of 90º perpendicular to the transect as a starting point. In the angle, 90º looked for the nearest tree and pole within and a distance didn't more than 25 meters from the transect, then recorded the species and measured diameter, height and distance pole to previous pole or tree to the previous tree. The measured tree is then considered as a next quadrant (2nd quadrant) with made an angle of 90º perpendicular parallel to transect, looked for tree or pole closest to the center point of 2nd quadrant and did it procedure until the end of the transect (Kurniawan et al. 2019). Simply put, the wandering quarter method can be described on Figure 2, where K1-K4 is quadrant, d1-d4 is the distance between trees. The criteria for trees and poles used are as follows (Kurniawan et al. 2019), with tree category: >35 cm and pole category: >10-35 cm. The way to identify the type of vegetation was founded by asking local names to the field guide and using a study of journal literature vegetation analysis that has been carried out in the Tahura R. Soerjo area. To find out which species are consumed and what part is consumed by the Javan lutung, using a study of journal literature that asked JLC captive managers.

Data analysis

Plant composition

Vegetation analysis using the wandering quarter method to determine the Important Value Index (IVI) with the equation:

$$\text{Average tree distance (m)} = \frac{\text{Total distance}}{\Sigma \text{ whole individual}}$$

$$\text{Density of all species per Ha (KH)} = \frac{10000}{(\text{Average tree distance})^2}$$

$$\text{Quantity in quadrant} = \frac{\Sigma \text{ all individuals of a species at all points}}{\Sigma \text{ total quadrant at all points}}$$

Quantity of trees per Ha (Density) = quantity in the quadrant of a type x KH

$$\text{Average basal area} = \frac{\Sigma \text{ basal area of a species}}{\Sigma \text{ all individuals of a species at all points}}$$

Dominance of a species = Σ basal area x number of trees per Ha of a species

$$\text{Relative dominance (\%)} = \frac{\text{dominance of a species}}{\Sigma \text{ domination of all species}} \times 100\%$$

$$\text{Frequency of a type} = \frac{\text{number of points found of a species}}{\text{Total point}}$$

$$\text{Relative frequency (\%)} = \frac{\text{Frequency of a species}}{\Sigma \text{ frequency of all species}} \times 100\%$$

$$\text{Relative density (\%)} = \frac{\text{Density of a species}}{\Sigma \text{ Density of all species}} \times 100\%$$

Important value index (IVI) = Relative frequency + Relative dominance + Relative density

Plant distribution index

The spatial distribution pattern of forage plants was analyzed using the Morisita distribution index (Hidayat 2014), with the equation:

$$I_d = n \times \frac{(\Sigma x^2 - \Sigma x)}{(\Sigma x)^2 - \Sigma x}$$

Where, I_d: dispersia Morisita index; n: number of sampling plots; $\sum x$: total number of individuals of a species in acommunity; $\sum x2$: sum of squares of the total individuals of a species in a community.

If the value of Id = 0 then the similarity of the community is low, while $I\delta = 1$ then the similarity of the community is high / equal. While the distribution patterns is shown by uniform index (Mu) and clumped index (Mc) calculations, including:

$$Mu = \frac{\chi^2 0.975 - n + \Sigma x}{(\Sigma x) - 1}$$

$$Mc = \frac{\chi^2 0.025 - n + \Sigma x}{(\Sigma xi) - 1}$$

Where, Mu: Morisita Index for uniform patterns; X^2 0.975: Chi-square table value with n-1 free degree and 97.5% confidence interval; Mc: Morisita index for clustering patterns; X^2 0.025: Chi-square table value with n - 1 free degree and 2.5% confidence interval.

Morisita degree standards are calculated by the formula:

$$Ip = 0.5 + 0.5 \left(\frac{Id - Mc}{n - Mc} \right) ; \text{if } I_d \geq Mc > 1.0$$

$$Ip = 0.5 \left(\frac{Id - 1}{Mc - 1} \right) ; \text{if } Mc > I_d \geq 1.0$$

$$Ip = -0.5 \left(\frac{Id - 1}{Mc - 1} \right) ; \text{if } 1 \geq I_d > Mu$$

$$Ip = -0.5 + 0.5 \left(\frac{Id - Mu}{Mu} \right) ; \text{if } 1 > Mu > I_d$$

Based on the Ip value, it can be concluded that the distribution pattern is uniform distribution if Ip < 0, random distribution, if Ip = 0, and clump distribution if Ip > 0.

Species diversity index

The diversity of species contained in an ecological unit can be known from the Shannon-Wiener index (Ismaini et al. 2015), with the following formula :

$$H' = - \sum (ni/N) \ln (ni/N)$$

Where, H' is the diversity in a circle of a species, ni is the number of individuals of the ith species, N is the total number of individuals of all the species, and ln is the natural logarithm. With criteria if H' ≤ 1 = low diversity, if 1 < H' < 3 = medium diversity, if H' ≥ 3 = high diversity.

Species richness index

Species richness in an ecosystem uses the Margalef Index (Ismaini et al. 2015), with the equation:

$$D_{mg} = \frac{S-1}{\ln N}$$

Where, D_{mg} is margalef index, S is the number of species observed, N is the total number of individuals observed, and ln is natural logarithm. With criteria if D_{mg} < 2,5 = low level of richness, 2,5 > D_{mg} > 4 = medium level of richness, D_{mg} > 4 = high level of richness.

Species evenness index

To find out the evenness of species in an area, the evenness value can be measured (Ismaini et al. 2015), with the formula:

$$E = \frac{H'}{\ln S}$$

Where, E is evenness index, H' is diversity index, S is the number of species observed, and ln is natural logarithm. With criteria E ≤ 0.4 = low evenness, 0.4 < E < 0.6 = medium evenness, E ≥ 0.6 = high evenness.

Similarity index

To see the similarity of the communities compared in each observation path with Sorensen Similarity Index (Abdullah et al. 2015) uses the following formula:

$$IS = \frac{2C}{A + B} \times 100\%$$

Where, IS is Sorensen index, A is number of vegetation types in transect 1, B is number of vegetation types in transect 2 and C is the same number of vegetation types is in transect 1 and 2. With criteria if IS < 50 % = low similarity index, if IS > 50 % = high similarity index.

RESULTS AND DISCUSSION

Vegetation composition of Javan langur habitat in Blue Mountain

On Gunung Biru found 45 plant species, including 45 types of pole-level vegetation and 26 types of tree-level vegetation, all of the plant species obtained were included in the category of forage sources for Javan langurs. The diversity of vegetation both at the pole and tree levels is quite varied, high for diversity of pole (H' 3.27) and moderate for diversity of tree (H' 2.54). Based on calculation of Index Value Importance (IVI) tree was *Quercus sondaicus* (42.33%), *Homalanthus giganteus* (101.62%) and *Engelhardia spicata* (83.62%). IVI for pool was *Q. sondaicus* (38.17%), *Acmena acuminatissima* (22.01%) and *H. giganteus* (28.96%). That species of vegetation is Javan langur's species of feed.

Distribution, richness and evenness of vegetation

The distribution of plants is divided into three primary patterns: random, uniform or clumped. The distribution pattern of the Javan langur food plant species in the Gunung Biru forest was classified as clustered at pole and tree vegetation, indicating the close distance between the stands. The species richness of both poles and trees is high, with 47 species of plants found in Blue Mountain. The value of species richness depends on the number of plants found in the plot (Nahlunnisa et al. 2016). The placement of a suitable measuring plot can describe the forest area still intact in Gunung Biru. The wider the sample plot or plot can be maximized with the number of observation points, the more information about the value of species richness (Hoffmann et al. 2019). The evenness of trees and poles in the Gunung Biru forest shows a high value. The number of different individuals in each species encountered causes the community to have a maximum evenness value (Ismaini et al. 2015).

Similarity

The similarity and dissimilarity of vegetation community types in each lane in the protected forest on the Gunung Biru. A comparison was made between the three observation lines at the pole and tree level. Based on the analysis, the dissimilarity value between paths is above 70% and similarity is less than 50% which shows that the levels of poles and tree species found are different.

Table 1. Part of the potential of plants consumed by the Javan Lutung in Gunung Biru forest, Batu City, East Java, Indonesia

Species	Growth from		Part of plant			Note
	Pool	Tree	Leaf	Flower	Fruit	
Acer laurinum	✓	✓	✓			Staf JLC
Acidendron sp.	✓		✓			Kurniawan et al. 2019
Acmena acuminatissima	✓	✓	✓	✓		Staf JLC
Acronicia trifoliata	✓		✓			Staf JLC
Ardisia javanica	✓		✓			Staf JLC
Articia homilis	✓		✓			Mustari and Pasaribu 2019
Bischofia javanica	✓		✓			Zakki et al. 2017
Casuarina junghuniana	✓	✓	✓			Staf JLC
Cordia sp.	✓	✓	✓			Staf JLC
Croton hirtus	✓	✓	✓			Kurniawan et al. 2019
Elaeocarpus glaber	✓	✓	✓	✓		Nurul 2015
Elicia srata	✓		✓			Staf JLC
Emaneli sp.	✓		✓			Staf JLC
Engelhardia spicata	✓	✓	✓	✓		Wedana et al. 2013
Ficus sp.	✓		✓	✓		Wedana et al. 2013
Ficus lepicarpa	✓		✓	✓	✓	Staf JLC
Ficus padana	✓	✓	✓	✓	✓	Mahbuby 2017
Fitus forumtobira	✓	✓	✓			Staf JLC
Garuga floribunda	✓	✓	✓		✓	Kurniawan et al. 2019
Glochidion rubrum		✓	✓			Ayunin 2014
Hellicia crata	✓		✓			Staf JLC
Homalanthus giganteus	✓	✓	✓			Wedana et al. 2013
Saurauia cauliflora	✓		✓			Wedana et al. 2013
Laportea stimulans	✓		✓	✓		Zakki et al. 2017
Macropanax dispermus	✓	✓	✓			Wedana et al. 2013
Mallotus sp.	✓	✓	✓			Staf JLC
Manglietia glauca	✓		✓		✓	Staf JLC
Melastoma sp.	✓		✓			Staf JLC
Melastoma malabathricum	✓	✓	✓			Staf JLC
Miren sp.	✓		✓			Staf JLC
Ardisia elliptica	✓		✓			Staf JLC
Cinchona succirubra	✓	✓	✓			Staf JLC, Nurul 2015
Podocarpus imbricatus	✓		✓			Staf JLC
Podocarpus neriifolius	✓		✓			Staf JLC
Prunus sp.	✓	✓	✓			Nurul 2015
Quercus sondaicus	✓	✓	✓		✓	Zakki et al. 2017
Quercus teysmannii	✓	✓	✓			Zakki et al. 2017
Saurauia bracteosa	✓		✓	✓	✓	Mahbuby 2017
Schima wallichii	✓	✓	✓			Mahbuby 2017
Slonia sigun		✓	✓			Wedana et al. 2013
Syzygium cumini	✓		✓			Staf JLC
Syzygium sp.	✓	✓	✓			Wedana et al, 2013
Trema orientalis	✓	✓	✓			Mahbuby 2017
Turpinia sphaerocarpa	✓	✓	✓			Zakki et al. 2017
Vernonia arborescens	✓	✓	✓			Wedana et al. 2013

Table 2. Distribution, richness and evenness of potential vegetation plant of Javan Langur in Gunung Biru, Batu City, East Java, Indonesia

Vegetation level	I_d	Mu	Mc	Ip	D_{mg}	E
Pole	0.987	0.971	1.079	0,081[a]	6.916*	0.874*
Tree	0.968	0.946	1.149	0.106[a]	4.461*	0.789*

Note: [a] Distribution pattern Ip > 0 is clustered/clumped; * high criteria is E ≥ 0,6 and D_{mg} > 4

Table 3. Similarity and dissimilarity index values pole each transects

IS (%) ID(%)	1	2	3
1	-	28.30	23.10
2	71.70	-	22.67
3	76.90	77.33	-

Table 4. Similarity and dissimilarity index values tree each transects

IS (%) ID(%)	1	2	3
1	-	12.09	15.73
2	87.91	-	15.55
3	84.27	84.45	-

Discussion

The types of plants found in the study include those used as food for Javan Langurs, which is a sign if the forest in Gunung Biru can be a habitat for animals to be released into the wild. This is also supported by the types of plants that are classified as diverse, so that are classified as diverse so that the availability of types of feed is met. These types of forage plants are mostly consumed on the leaves, which contain high protein to meet the needs of life (Li et al. 2020). Potential of several types of food plants in Gunung Biru was a high importance value index (IVI). Including the highest scores, such as *Q. sondaicus* and *H. giganteus.* Both at the tree and pole levels, so a high IVI value can guarantee regeneration for this species (Ismail et al. 2017) to become food plants for the Javan Langur in Gunung Biru. Potential plants with high density can be ideal conditions for Javan langurs because tree crowns can overlap, which is helpful for moving from one tree to another (Sari et al. 2020). Forest communities with vegetation structures such as natural forests can be a habitat for Javan langurs trees to provide protection, food, shelter and breeding (Diniyati 2015; Tolangara et al. 2019).

The composition of the vegetation in Gunung Biru forest is a pattern of distribution of both trees and high pools. It benefits for Javan langur because it has no difficulty finding food. The high evenness also makes it easier for animals to move around looking for food, animals looking for food to maximize fitness. Feeding by animals to get nutrients and calories again after losing most of the energy for foraging, looking for places to eat and choosing food (Clark and Begley 2015). It is very complex and has many factors, namely the amount of energy needed in moving mode (walking, running, jumping, flying), environmental conditions, seasons, distribution of food sources, presence of predators and competitiveness (Clark and Begley 2015; Dutta 2019).

The potential for highly diverse plant species indicates that the Gunung Biru forest is still intact and the impact of natural biodiversity is more significant than in artificial ecosystems such as production forests (Flombaum and Sala 2008). That shows the condition of the forest stands in Gunung Biru is still maintained. Undamaged forest ecosystems provide a source of food and habitat, thereby increasing biodiversity (Mahajan and Patil 2014). Species diversity in an area depends on the number of species observed and the total number of individuals (Brenda et al. 2018). High species diversity is positively correlated with increased stability in an ecosystem (Loreau and Claire 2013; Lucini et al. 2020). It showed the forest on Gunung Biru in good condition, with low human activities entering the forest that can threaten the habitat and wildlife species. The similarity of vegetation on each transect was found to be low, confirming that the forest in Gunung Biru has high species richness and potential for diverse food trees for Javan langurs that will be released into the wild by the JLC. The potential sources of forage plants in Gunung Biru are not yet known to be able to support the number of Javan langur populations. This is to prevent competition between individuals and groups.

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