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Journal of Threatened Taxa

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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

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26 April 2019 | Vol. 11 | No. 6 | Pages: 13667–13679
DOI: 10.11609/jott.4781.11.6.13667-13679

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Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2019 | 11(6): 13667–13679

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Resource selection by Javan Slow Loris *Nycticebus javanicus* E. Geoffroy, 1812 (Mammalia: Primates: Lorisidae) in a lowland fragmented forest in Central Java, Indonesia

Mahfut Sodik [1], Satyawan Pudyatmoko [2], Pujo Semedi Hargo Yuwono [3] & Muhammad Ali Imron [4]

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Abstract: Habitat loss and forest fragmentation have negative impacts on Javan Slow Loris *Nycticebus javanicus*, a Critically Endangered nocturnal primate endemic to Java. Reports confirmed that less than 9% of forest area remains on Java Island. One of the remaining natural habitats of the Javan Slow Loris is the fragment of Kemuning Forest in Temanggung Regency, Central Java. The purpose of this study was to determine resource selection and habitat variables that determine the presence of Javan Slow Loris. Habitat variables measured were basal area, tree connectivity, crown coverage on tree stage, slope, elevation, and distance to river. Data analysis performed was logistic regression, likelihood ratio test, and Akaike's Information Criterion with a backward elimination procedure. We also used direct observation and interviews with locals to collect data on environment and anthropogenic features of this forest. The results showed that the Javan Slow Loris uses resources selectively on a microhabitat scale. The habitat factors that influence the probability of resource selection by the species are canopy cover and slope. Habitat characteristics preferred by the Javan Slow Loris in Kemuning Forest are secondary lowland tropical rainforest with dense canopy cover located on a steep slope with low level of habitat disturbances. Although this study uses a small sample size, the expectation is that the results can be used as preliminary information for the habitat and population management of Javan Slow Loris in Kemuning Forest to guide conservation efforts and design management strategies.

Keywords: Forest fragment, habitat characteristics, Kemuning Forest, logistic regression, microhabitat, resource selection, threatened taxa.

DOI: https://doi.org/10.11609/jott.4781.11.6.13667-13679

Editor: Mewa Singh, University of Mysore, Mysuru, India. **Date of publication:** 26 April 2019 (online & print)

Manuscript details: #4781 | Received 26 December 2018 | Final received 15 February 2019 | Finally accepted 27 February 2019

Citation: Sodik, M., S. Pudyatmoko, P.S.H. Yuwono & M.A. Imron (2019). Resource selection by Javan Slow Loris *Nycticebus javanicus* E. Geoffroy, 1812 (Mammalia: Primates: Lorisidae) in a lowland fragmented forest in Central Java, Indonesia. *Journal of Threatened Taxa* 11(6): 13667–13679. https://doi.org/10.11609/jott.4781.11.6.13667-13679

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Funding: Program Rekognisi Tugas Akhir (RTA) Universitas Gadjah Mada Yogyakarta Tahun 2019 dan beasiswa Kementrian Lingkungan Hidup Republik Indonesia.

Competing interests: The authors declare no competing interests.

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Author contribution: MS, SP and MAI conceived the idea; MS collected data; MS, SP, and MAI performed the analysis; SP led the writing; all authors contributed to the writing draft and approved the final version.

For **Bahasa Indonesia Abstract** see end of this article.

Acknowledgements: The authors would like to thank Febriyanto Ismu Nugroho, mas Jum, mas Dayat, mas Edwar, Tungga, Eni, Donna Susanti, cheennal, mas Rian, mas Budi, Make, Pake, for all the help and support with the fieldwork for this study. We are also grateful to the chief of Kemuning Village and Perhutani of Kedu Utara managers for granting access to the site. Anna Nekaris for an insightfull discussion. Anonymous reviewers who provided critics and feedback for our manuscript. The Wildlife Conservation Centre of forestry faculty Gadjah Mada University was of invaluable use as provided comfortable working and discussion place.

INTRODUCTION

The Javan Slow Loris (Image 1) is a nocturnal, arboreal primate endemic to Java, Indonesia (Ross et al. 2014). It is categorized as a Critically Endangered species by the IUCN (Nekaris et al. 2013) and is protected by CITES under Appendix I, banning international trade for commercial purposes. This species is also included in the 25 most endangered primates in the world (Nekaris et al. 2008; Mittermeier et al. 2009; Voskamp et al. 2014; Schwitzer et al. 2017). In Indonesia, the Javan Slow Loris is highly protected under Law No. 5 of 1990 concerning Conservation of Natural Resources, and the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.20/ MENLHK/ SETJEN/ KUM.1/ 6/2018 dated 29 June 2018 on Types of Protected Plants and Animals.

Although the Javan Slow Loris has a wide range (Nekaris et al. 2008; Thorn et al. 2009) including human-dominated landscapes (Voskamp et al. 2014), habitat loss and forest fragmentation in Java has had a significant impact on the survival of this nocturnal species. Java is one of the most populated islands in the world, with 1,071 inhabitants per square kilometre (Rode-margono et al. 2014). It is subject to increasingly high rates of deforestation, habitat fragmentation, local extirpation of species (Chettri et al. 2018), and other impacts related to rapid population increase and industrialization. Research confirmed that less than 9% of forest area remains in this area. Most are montane forests, with only a very small amount of lowland forest remaining (Balen 1999; Reinhardt et al. 2016).

Among the remaining small fragments of lowland tropical forests, a small population of Javan Slow Loris can be found in Kemuning Forest of Central Java (Siregar 2014; Krisanti et al. 2017). Kemuning Forest is a part of a production forest area managed by the Indonesian State Forest Company (Perum Perhutani) of Kedu Utara Unit Management. Agroforestry shade-grown coffee plantations were implemented by Perum Perhutani with Collaborative Forest Management System (CBFM) in Kemuning Forest (Ahmad 2017; Krisanti et al. 2017). Currently, research of the Javan Slow Loris is limited to conservation areas (Nekaris 2014) and plantations or agroforestry areas (Wirdateti 2012; Nekaris et al. 2017). Research on the Javan Slow Loris in lowland tropical fragmented forests with the presence of shade-grown coffee plantation is still scarce.

Resource selection is an important factor for understanding the relationship between habitat and wildlife (Manly et al. 2002). Selection studies usually deal with food or habitat selection. There are two different categories of habitat selection, that among various discrete habitat categories (e.g., open field, forest, and rock outcropping) and that among a continuous array of habitat attributes (such as shrub density, percentage cover, distance to water, and canopy height; Manly et al. 2002). The resource selection model can be obtained by applying logistic regression analysis. The logistic regression method is suitable for analyzing the selection of several habitat variables and also dichotomous data in the form of the presence and absence of the Javan Slow Loris. A logistic regression analysis produces a resource selection function (RSF; Manly et al. 2002) and demonstrates the probability value of usage on each of the resource variables by wildlife (Weins et al. 2008).

Image 1. Javan Slow Loris *Nycticebus javanicus*

Primate species among arboreal mammals are commonly selected to assess the effects of habitat disturbance as they rely on primary forest habitats and also have primary functions as predators, seed dispersers (Kays & Alisson 2001), and ecosystem balance keepers (Basalamah et al. 2010). To understand how a nocturnal arboreal primate responds to habitat disturbance, especially in a lowland fragmented forest, we conducted research to determine the microhabitat factors that influence the presence of the Javan Slow Loris on a microhabitat level in Kemuning Forest. The main question asked in this research was whether the Javan Slow Loris performs resource selection at the microhabitat level in the lowland fragmented forest of Kemuning Forest. Therefore, our research hypotheses were 1) the Javan Slow Loris has its own habitat characteristics and performs resource selection at the

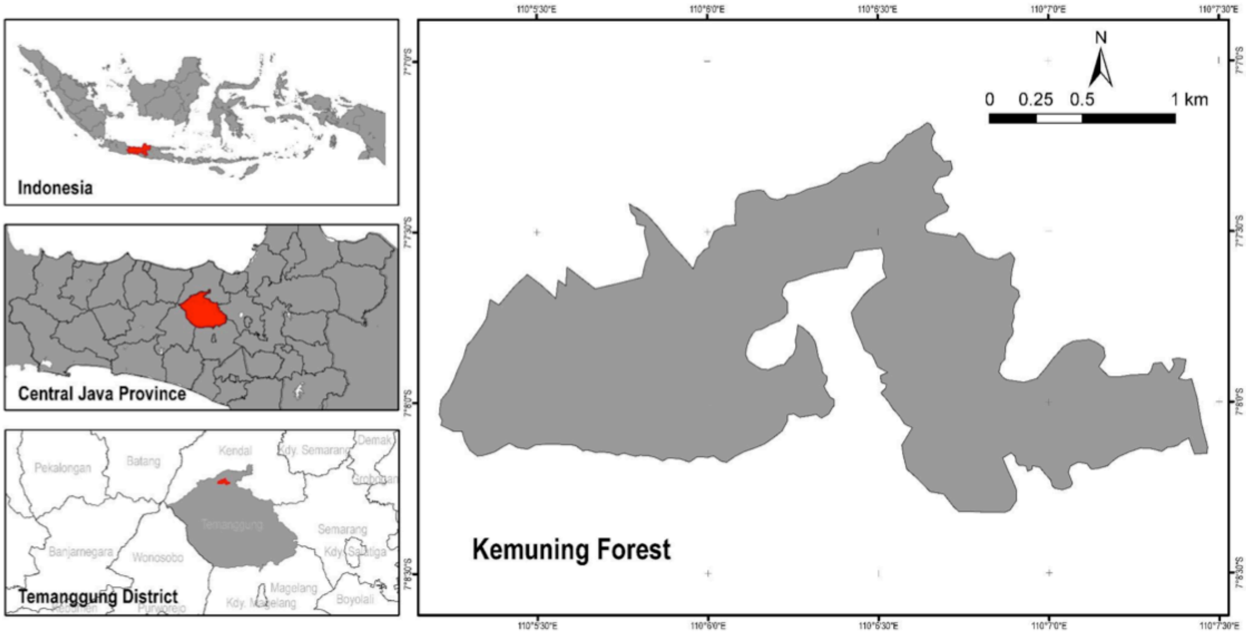

Figure 1. The study area in Kemuning Forest, Central Java, Indonesia.

microhabitat level in the lowland fragmented forest of Kemuning Forest and 2) environment factors influence resource selection by the Javan Slow Loris at the microhabitat level in the lowland fragmented forest of Kemuning Forest.

MATERIALS AND METHODS

Study Area

The research was conducted in the Kemuning Forest, Bejen District, Temanggung Regency, between February and October 2017. Geographically, Kemuning Forest is located at 110.086–110.124 BT & -7.119–-7.138 LS. Kemuning Forest, which has an area of approximately ±373ha (Fig. 1), is a part of a production forest area that functions especially for protected forests managed by the Indonesian State Forest Company (Perum Perhutani) of Kedu Utara Unit Management. There is an enclave village called Desa Kemuning within the forest area and most of the locals practice agroforestry management such as shade-grown coffee in the forest area. The agroforestry system is a collaborative scheme between Perum Perhutani and the Kemuning villagers.

According to the Schmidt-Ferguson classification system, this study area falls under wet climate (B climate classification (Sugiyanto 2017)) having characteristics with rainfall over the past nine years ranging from 2,176mm/yr to 4,649mm/yr. The average rainfall is 2,931mm/yr and monthly rainfall is 245mm/yr (Sugiyanto 2017). In general, topographic conditions in the study area are dominated by steep slope categories and this remaining tropical lowland forest has an altitude range between 300m and 600m.

Night surveys

We performed night surveys to detect the presence of the Javan Slow Loris in Kemuning Forest. Five repeated night surveys in 2017 were used as the main basis of data analysis. The night surveys were carried out using occupancy techniques (MacKenzie et al. 2002) by dividing the study area into 141 grids with the dimension of 200m x 200m (4ha) each. This grid size was adjusted to the size of the smallest home range of the slow loris in a disturbed natural forest, which is 2.8ha (Fig. 2; Wiens 2002; Nekaris et al. 2013). Vegetation types in the given area were recorded along the transects, as were any signs of disturbance or sources of threat to the Javan Slow Loris. Additionally, we also interviewed the local people to obtain information on the location of sightings of Javan Slow Loris, the management of the agroforestry system, and the threats that the species faces.

The night survey started at 18.00–19.00 h and finished at 23.30–03.00 h (Pliosungnoen et al. 2010). In general, the night survey was between 18.00h and 03.00 h. We are aware that the active time of the species is 18.00h to 06.00h (Nekaris 2003; Wiens & Zitzmann 2003); however, due to weather and physical conditions

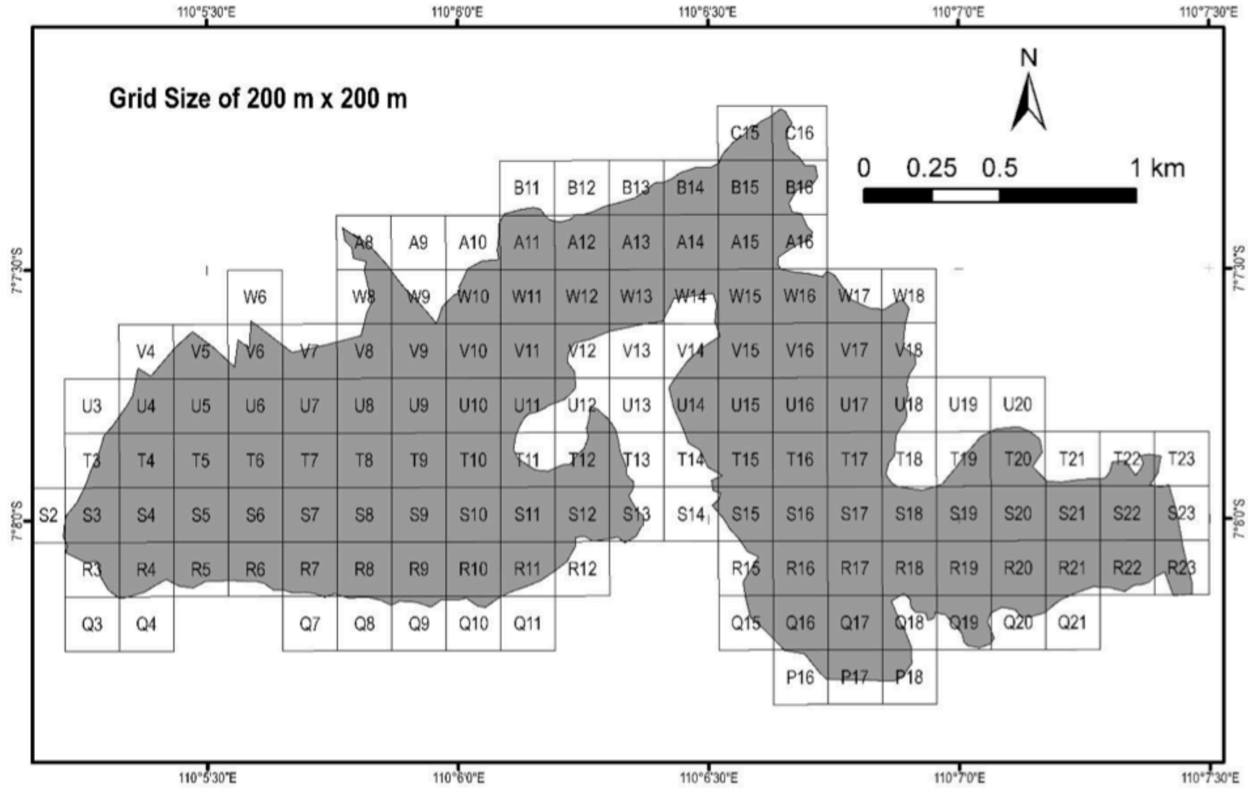

Figure 2. Grid size of 200m x 200m of the study area in Kemuning Forest, Central Java, Indonesia.

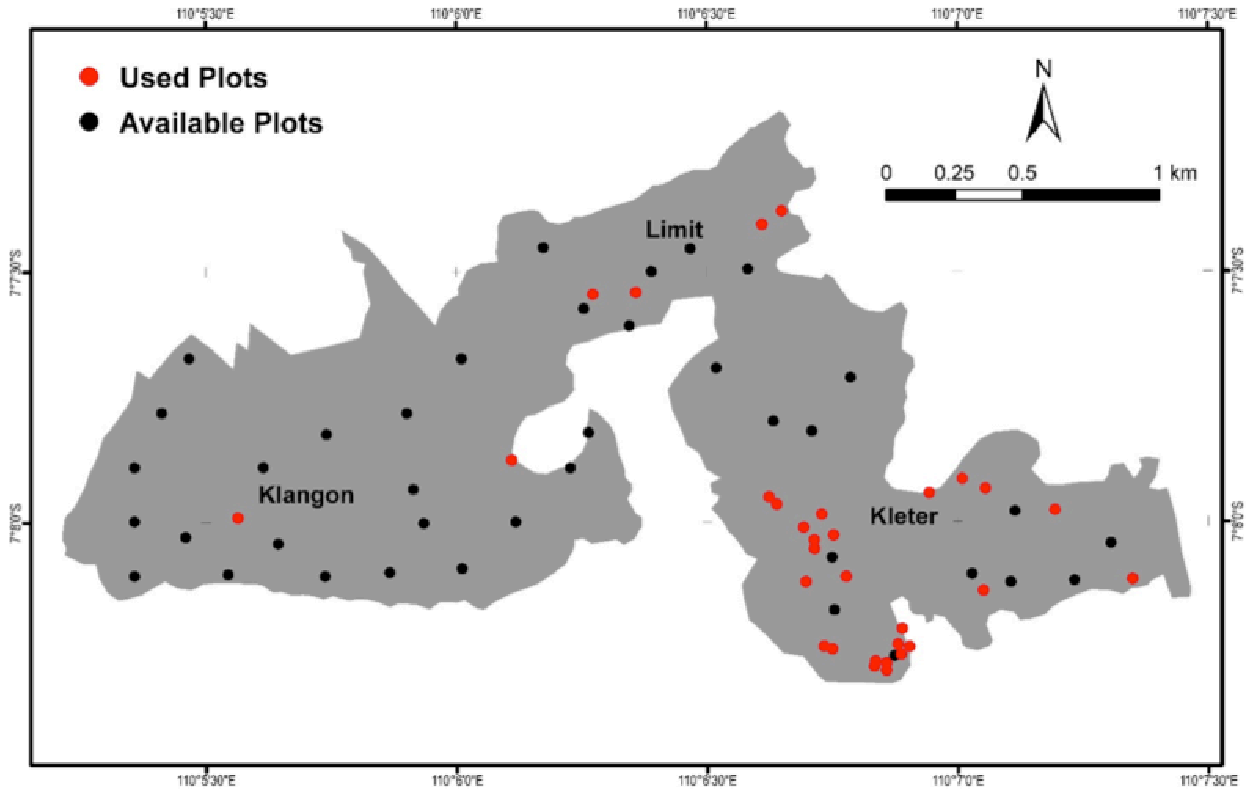

Figure 3. Used and available plots within the study area in Kemuning Forest, Central Java, Indonesia.

of observers, the observation occasionally had to finish earlier. We walked along the existing walking paths at a slow speed of maximum 800m/h (Nekaris et al. 2014) and stopped every 20m to conduct observations for 5–15 min. To distinguish the Javan Slow Loris from other nocturnal arboreal mammals, we used a yellow filter lamp. In order to reduce interference, however, a red filter lamp was utilized to observe individual slow lorises as suggested by Nekaris et al. (2008). The observation team consisted of only two people to minimize disturbance to the animals (one observer and one assistant; Nekaris 2003). If a Javan Slow Loris was spotted and identified during the night surveys, its location in the study area and time of night were noted. Each tree used by the slow loris was marked with flagging tape, with a different sign for each individual animal.

The following data was collected for each sighting: the number of individuals, height in tree, activity when first detected, tree species, and geographic coordinates (Nekaris et al. 2008). We collected microhabitat data used by the Javan Slow Loris from an available plot that was determined previously by random method as well as on the used plot (plot used by the Javan Slow Loris) determined in the field using a search sampling method (Morrison et al. 2001). The 20m x 20m (0.04ha) plot size was applied to measure the vegetation variables (Fig. 3).

The microhabitat variables measured in this study were biotic and abiotic components, i.e., the average of branch tree height (X_1), the average of tree height (X_2), basal area (X_3), tree connectivity (X_4), crown coverage on tree stage (X_5), slope (X_6), elevation (X_7), distance to road (X_8), distance to settlement (X_9), and distance to river (X_{10}).

The biotic variable measurement was calculated with nested sampling for vegetation measurements at tree level (DBH≥10cm; Pliosungnoen et al. 2010). The canopy cover measurement was calculated using a vertical tube (Johansson 1985; Morrison 2002). The slope was obtained using clinometers and the elevation was found using the feature on the GPS receiver. The measurement of the distance to river, settlement, and road was done using QGIS software. All measurements of trees and plots were conducted within the same season when the animal was observed (Pliosungnoen et al. 2010). Identification of plant species was carried out by herbarium collection, checking the local name, and through the database in the forestry faculty of Gadjah Mada University.

Analysis

We performed comparison analysis between used and available resources using T-Test for normal data, or Mann-Whitney U-test for non-normal data after the Shapiro-Wilks normality test. We carried out a multicollinearity test to all variables measured to see whether there is no high degree of multicollinearity among the independent variables indicated by variance inflation factor (VIF) value less than four (Pan & Jackson 2008; Hair et al. 2014). Any variable with a VIF value that exceeded four was excluded from the model.

To find out the microhabitat components that influence the probability of the presence of the Javan Slow Loris, a logistic regression analysis was performed following Manly et al. (2002). The selection of the best logistic regression models was based on the Akaike's information criterion (AIC). The best equation model was determined based on the smallest AIC value.

We applied a step-wise procedure from the logistic regression model with a backward elimination method. Therefore, habitat variables with the lowest significance value (*p*-value) were eliminated from the logistic regression model in stages. The result of the best model was tested with goodness of fit (Hosmer & Lemeshow 2000) and the differences between the models and the observation data were then tested with chi-square test (Hosmer & Lemeshow 2000). All statistical analysis was run with R 3.5.2 statistical data processing package.

RESULTS

Javan Slow Loris encounters at Kemuning Forest

We covered the entire area of Kemuning Forest while conducting five repeated surveys, in which we held 50 night surveys over the course of ±225.75h. We recorded 33 loris encounters (32 solitaries and one pair; Fig. 4). The distribution of the Javan Slow Loris in Kemuning Forest was clustered in three different locations: in Kleter with 26 individual encounters, in Klangon with two individual encounters, and Limit with five encounters. The Javan Slow Loris used 17 different tree species (Table 1 & 2). The most commonly used tree species by lorises in Kemuning Forest were *Sterculia oblongata* and *Aphananthe cuspidata* (Blume) Planch. The average tree height used by the Javan Slow Loris was 21.7m, while the average tree diameter used was 0.70m. The Javan Slow Loris was mostly found at an average height of 14.18m above the ground.

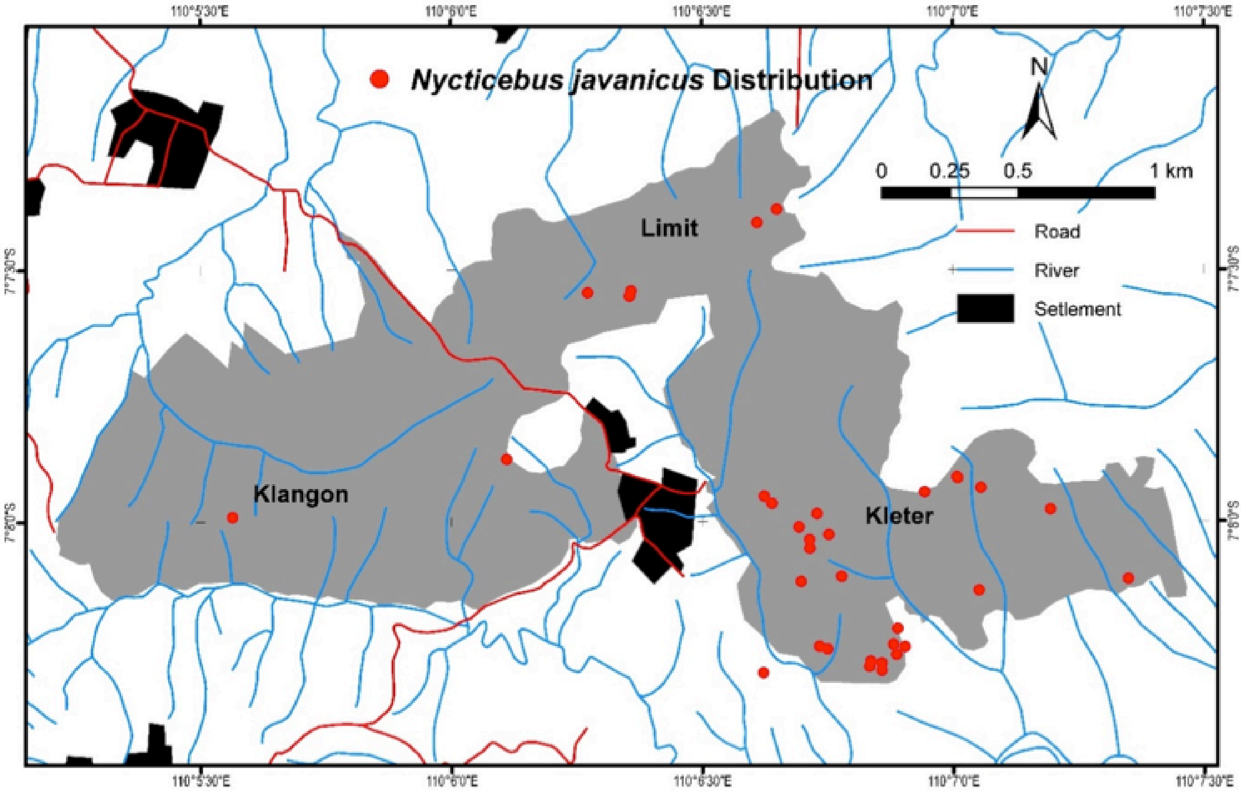

Figure 4. Javan Slow Loris encounter during night surveys in Kemuning Forest, Central Java, Indonesia.

Habitat characteristics at Kemuning Forest

Ten microhabitat variables in Kemuning forest obtained based on the result of the measurements of habitat characteristics (Table 3). There are four microhabitat variables that significantly influenced the presence of Javan Slow Loris in the study area: basal area, tree connectivity, crown coverage on tree stage, and slope (Table 4). The study area is dominated by a low basal area of trees with the value of 1000–3000 cm^2/ha. Some plots have a very high tree basal area value even with very low frequency (Fig. 5). There were significant differences between used plot and available plot (Mann-Whitney U-test (p=<0.05). The tree connection data in the study area was dominated by trees with the connectivity of 40–70 %, while trees with 100% connectivity were very small (Fig. 5). The result showed that used and available plots are significantly different (T-test, p=<0.01). The crown coverage in the study area was dominated by a dense canopy (Fig. 5). There was a significant difference between used and available plot of the crown coverage (Mann-Whitney U-test, p=<0.01). In general, the study area has a steep slope. The Mann-Whitney U-test result showed significant differences (p=<0.01) between used and available plots.

Resource selection by Javan Slow Loris in Kemuning Forest

The multicollinearity test resulted in six variables that are free from high degree of multicollinearity out of ten variables (Table 5). Those variables are basal area, tree connectivity, crown coverage on tree stage, slope, elevation, and distance to river. These six variables were further elaborated and analyzed.

The logistic regression analysis produced a deviation of 93.738 with 67 df for the model with predictors, while the deviation for the null model was 44.782 with 61 df. The difference in deviation was 48.956 with 6 df. The chi-square test result (p=<0.01) showed a significant difference, suggesting that there is at least one independent variable that affects the dependent variable. This shows that Javan Slow Loris performs a selection of certain resources to meet its needs.

There were two microhabitat variables (crown coverage β=0.1934±0.06528, and slope β= 0.114±0.04518) of the six variables tested which had a significant effect on the presence probability of Javan Slow Loris in the study area (Table 6). Four variables, however, did not significantly influence the presence probability of the species. The elimination procedure was performed in four stages to obtain the smallest

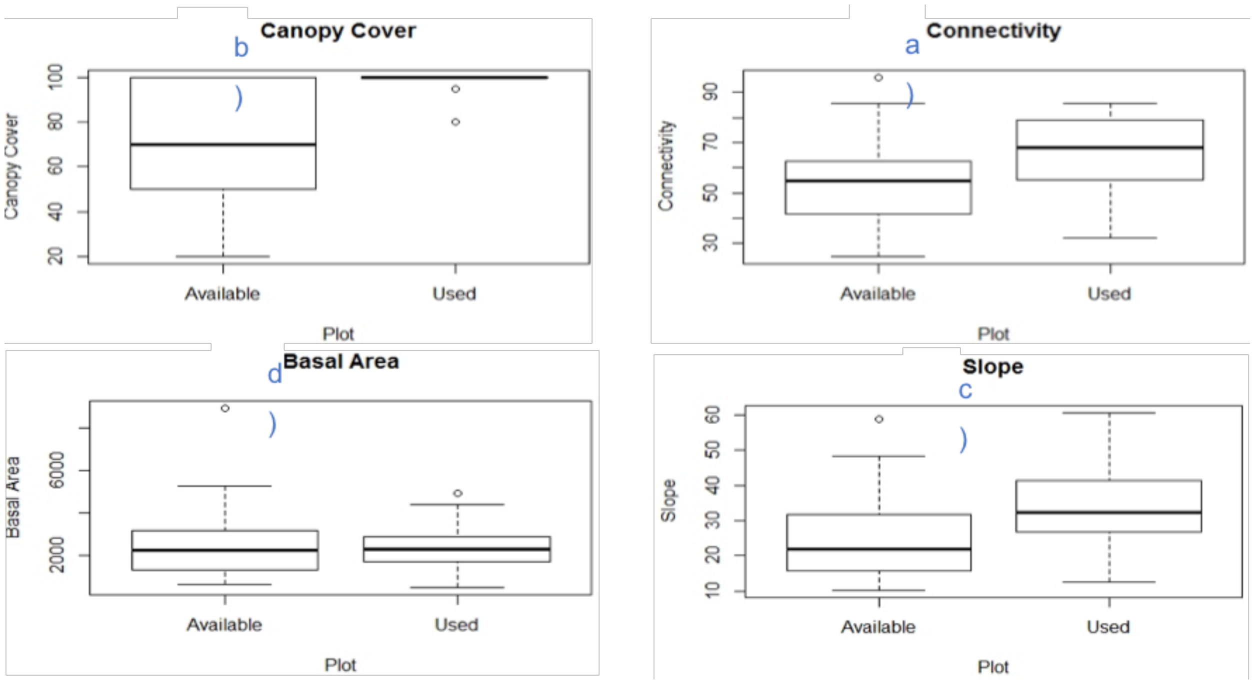

Figure 5. Comparison of distribution data between used and available plots in Kemuning Forest, Central Java, Indonesia: a) connectivity (%) | b - canopy cover (%) | c - slope (%) | d - basal area (cm^2/ha).

Table 1. Ethogram of the behaviour of Javan Slow Loris

Alert	: Resting but still observing the surroundings or the observer.
Feeding	: Eating food.
Foraging	: Movement related to foraging (including visual and olfactory searches that may have a social context but are difficult to describe).
Social	: Interaction, including attack behaviour, grooming, or other social behaviour.
Travelling	: Continuously moving, moving forward from one place to another.
Freeze	: Making a little movement, standing upright, or in a sitting position for at least 3s, moving very slowly but not related to foraging activities.
Sleep	: There is no movement, the head is between the knees, eyes closed.
Groom	: Licking or bathing itself, licking its body using its tongue or a tooth comb on its body.
Rest	: Staying upright, the head position between knees, eyes closed.
Other	: Other behaviours that are not specified on the ethogram.

AIC value. The gradually eliminated variables from the logistic regression model were basal area, tree connectivity, elevation, and distance to river. The smallest AIC value was obtained in the fourth stage with AIC=55.071. Therefore, the results of the best statistical model remain in two microhabitat variables which influence the presence of the Javan Slow Loris in Kemuning Forest (Table 7). The Hosmer & Lemeshow goodness of fit test for the best model yields *p*-value (0.65)>0.05, which indicates that the logistic regression model is quite good (fit) and acceptable. The coefficient of determination (R^2L) of the logistic regression on the best model was 49.14. The coefficient of determination (R^2L) value showed that the independent variable was able to predict the presence of Javan Slow Loris in the Kemuning Forest by 49.14%. The logistic regression model to predict the presence of Javan Slow Loris in Kemuning Forest is as follows:

$$\pi = \frac{\exp(-18.741 + 0{,}168X1 + 0{,}103X2)}{1 + \exp(-18.741 + 0{,}168X1 + 0{,}103X2)}$$

where π is the presence probability of Javan Slow Loris, X1 is the crown coverage on tree stage, and X2 is the slope.

Table 2. Trees species used by the Javan Slow Loris in Kemuning Forest, Central Java, Indonesia.

Tree species	Family	Height (m)	Tree DBH (m)	Tree height (m)	Activity
Blumea balsamifera Dc.	Asteraceae	7	0.7	17	Foraging
Spondias pinnata (L.f.) Kurz	Anacardiaceae	13–25	0.4–1.6	19–35	Traveling
Aphananthe cuspidata (Blume) Planch	Cannabaceae	9–20	0.5–0.8	17–29	Alert, traveling
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	12	0.6	19	Traveling
Dillenia obovata (Blume) Hoogland	Dilleniaceae	9	0.8	17	Traveling
Albizia chinensis Morr.	Fabaceae	6	0.4	12	Traveling, social
Vitex pubescens Vahl	Lamiaceae	15	0.7	21	Traveling
Litsea velutina (Blume) Hook.f	Lauraceae	7	0.7	27	Foraging
Litsea glutinosa (Lour.) C.B. Rob.	Lauraceae	10–12	0.4–0.6	17–18	Traveling, alert
Sterculia urceolata Sm.	Malvaceae	12–20	0.4–1.2	17–35	Traveling, feeding
Dysoxylum gaudichaudianum (Juss.) Miq.	Meliaceae	6	0.1	8	Traveling
Adenanthera microsperma T. & B.	Mimosaceae	15	0.8	20	Alert
Artocarpus elasticus Reinw ex. Blume	Moraceae	17–19	1.1–1.3	27–28	Alert
Ficus sundaica Blume	Moraceae	20	1.1	27	Traveling
Ficus superba Miq.	Moraceae	15	0.9	22	Traveling
Bamboo	Poaceae	14	-	15	Alert
Nauclea subdita (Korth.) Steud.	Rubiaceae	13–15	0.3–1.1	17–28	Alert, feeding
	Mean	14.18	0.70	21.76	
	Std. deviation	5.05	0.31	6.57	

Table 3. Recapitulation of the microhabitat variables of the Javan Slow Loris in Kemuning Forest, Central Java, Indonesia.

Variable	Used			Available		
	Mean	Min	Max	Mean	Min	Max
The average of branch free height (m)	8,25	4,4	12,7	8,45	3	15
The average of tree height (m)	17,2	10,8	23,8	18,04	11,6	27
Basal area (cm²/ha)	2397.35	488.9	4943.5	2608.91	629.7	8929.9
Tree connectivity (%)	65.02	32.1	85.7	53.91	25	95.8
Crown coverage on tree stage (%)	99.03	80	100	71.22	20	100
Slope (%)	33.33	12.5	60.5	24.4	10.2	58.7
Elevation (%)	547.15	468.2	629.5	563.28	454.1	625.2
Distance to road (m)	660,4	224,4	1654,8	513,3	10,1	1229,8
Distance to settlement (m)	706,87	251,0	1608,1	693,99	68,3	1517,2
Distance to river (m)	108.87	27.8	186.1	86.74	8.3	190.3

DISCUSSION

Based on the results of the night survey, the Javan Slow Loris encounters in the different heights on trees ranged from 6–25 m in Kemuning Forest. Munds et al. (2013) stated that slow lorises can be found from the ground to as high as 30+m. The Javan Slow Loris, as a species in the family Lorisinae, is known as a habitat-dependent species for the height of the used tree (Nekaris 2014). Therefore, the Javan Slow Loris can be found on varied soil surface height depending on the habitat conditions. The Javan Slow Loris uses *Sterculia oblongata* and *Aphananthe cuspidata* (Blume) Planch tree species more often than other species in Kemuning Forest since this species possibly has a suitable canopy cover for Javan Slow Loris. A dense tree canopy provides food and protection from predators and extreme temperature exposure to the Javan Slow Loris (Nekaris 2014).

Habitat characteristics at Kemuning Forest

The Kemuning Forest consists of natural forest vegetation that is disrupted by human interference, one of the activities of which is a coffee plantation under the forest stands (the shade-grown coffee). The coffee plantation system adopts an agroforestry system which is performed intensively in this area. The agroforestry system, however, changes largely the conditions of the forest. Farmers sometimes reduce canopy cover and understorey to increase the penetration of sunlight to the forest floor. These activities were done by cleaning shrubs and all tree saplings, resulting in increasing coffee productivity. This condition is in line with the coffee management in Latin America where farmers adopted 'sun systems' that utilize fewer shade trees (Perfecto et al. 1996). This practice is done by eliminating larger canopy tree species to promote air exchange and increase light penetration. This practice, however, presents a significant threat to the native flora and fauna in the forest (James 2014).

Based on observations and interviews with locals, it was found that farmers have continued to cut down the bamboo stands as those were disturbing the existence of coffee plantation within the study area. Besides expanding the coffee plantation area, the goal of cutting bamboo stands was to increase coffee productivity. Research carried out in Cipaganti, West Java, reported that bamboo stands are the dominant vegetation of sleep sites for Javan Slow Loris and function as substrates for feeding and avoiding ground movement (Nekaris et al. 2017). This practice, in general, affects the presence of Javan Slow Loris in Kemuning forest.

Moreover, the intensity of coffee management varies among farmers. It depends on the access (distance from the road), the land condition, and the wealthiness of each farmer. In the case where the coffee plantation is closer to the road, has better land conditions, or is overseen by a wealthier farmer, it typically results in management that is more intensive. This caused a variation within the microhabitat conditions of the forest, especially the canopy cover and the vegetation structure. A diverse canopy under shade-grown coffee management is an important habitat for biodiversity, but removing shade trees, limiting shade cover, and using agrochemicals generally result in losses of biodiversity for epiphytes, arthropods, birds, and mammals (Perfecto et al. 1996, 2007; Moguel & Toledo 1999; Philpott et al. 2007), especially slow loris.

Habitat characteristics of Javan Slow Loris in Kemuning Forest consist of forest area with dense canopy cover, small basal area, dominated by trees that are connected to each other and steep slope. Thus, forest structure plays an important role in the habitat selection of arboreal mammals (Datta & Goyal 1996). Tree connectivity is very important for Javan Slow Loris activities, as this animal cannot jump or leap. Nekaris (2019) stated that slow loris is a unique primate genus in terms of its inability to leap or jump and strong precise grip to hold onto branches. Slow lorises must rely on slow and steady climbing, hence the name. They manoeuvre across gaps using all levels of forest structure, including the ground (Nekaris 2019). Therefore, the existence of trees with continuous canopy is a useful habitat for the Javan Slow Loris (Munds et al. 2013). The suitability of tree connectivity conditions is important for the Javan Slow Loris in terms of safety, moving, and avoiding predators.

The Javan Slow Loris in Kemuning Forest tends to use a small basal area. The area in a small basal area in tree stage per plot usually consists of a small number of individual trees with a larger diameter. Mbora & Meikle (2004) found that the larger basal area is suitable for a group primate, while the Javan Slow Loris is known as a solitary animal. Like other arboreal primates, Javan Slow Loris tends to choose larger trees as these are related to higher food abundance (Vidal & Cintra 2006; Pliosungnoen et al. 2010). The Javan Slow Loris in Kemuning Forest tends to choose an area with dense canopy cover. The suitability of canopy cover conditions is very important for the animal's safety, to avoid air predators as well as walking on the ground (Garber 1992) and also to provide food and protection from extreme weather (Nekaris 2014). Bolen & Robinson (2003) argued that two essential elements of wildlife habitat are food and shelter/ cover. Food provides nutrients for body substances and energy for vital processes of wildlife, while shelter protects wildlife from extreme weather and predators. The tree canopies fulfil two basic habitat elements for the Javan Slow Loris population in the Kemuning Forest. In certain conditions, wildlife may ignore human threats in order to get their favourite food (Purnomo & Pudyatmoko 2011). As a canopy dweller species, the Javan Slow Loris requires dense canopy cover conditions for its activities (Pliosungnoen et al. 2010). Ray et al. (2012) argued that arboreal nocturnal mammals tend to choose habitats with tight canopy cover greater than 75%. The average canopy cover on the used plot in Kemuning Forest habitat was higher

Table 4. Habitat characteristics comparisons on used plot and available plot of Javan Slow Loris in Kemuning Forest, Central Java, Indonesia.

Habitat variables	Test type	*P* value
The average of branch free height (m)	T-test	n.s
The average of tree height (m)	T-test	n.s
Basal area (cm^2/ha)	Mann-Whitney U-test	<0.05*
Tree connectivity (%)	T-test	<0.01*
Crown coverage on tree stage (%)	Mann-Whitney U-test	<0.01*
Slope (%)	Mann-Whitney U-test	<0.01*
Elevation (%)	Mann-Whitney U-test	n.s
Distance to road (m)	Mann-Whitney U-test	n.s
Distance to settlement (m)	T-test	n.s
Distance to river (m)	Mann-Whitney U-test	n.s

Table 5. Result of the multicollenearity test of the variables.

Variable	Multicollinearity test (VIF value)		
	Before	After	
The average of tree height	8.28	-	Eliminated
Distance to settlement	5.50	-	Eliminated
The average of branch free height	5.02	-	Eliminated
Distance to road	4.43	-	Eliminated
Slope	3.84	2.03	
Elevation	3.20	1.66	
Basal area	3.14	1.60	
Crown coverage on tree stage	2.56	1.89	
Distance to river	2.26	1.33	
Tree connectivity	1.77	1.40	

Table 6. Estimated parameter results of the logistic regression model.

Variable	Estimate (β)	Standard error	Z value	Pr(>|z|)
intercept	-29.64	11.87	-2.498	0.01250*
Basal area	0.0000288	0.0003438	0.084	0.93316
Tree connectivity	0.01146	0.02658	0.431	0.66643
Crown coverage on tree stage	0.1934	0.06528	2.963	0.00305**
Slope	0.114	0.04518	2.531	0.0139*
Elevation	0.01139	0.0115	1.022	0.3067
Distance to river (m)	0.009646	0.0074	1.304	0.19239

* indicated significant difference with p values < 0.05
** indicated stronger significant difference with p values < 0.001

Table 7. RSF coefficient estimation of the best model with backward elimination method.

variables	β	Std. Error	Z value	Pr(>|z|)
Intercept	-18.74082	6.12146	-3.061	0.00220**
Crown coverage on tree stage (%)	0.16812	0.05833	2.882	0.00395**
Slope (%)	0.10261	0.03743	2.742	0.00611**

** indicated stronger significant difference with p values < 0.001

than 75%, though the available plot was slightly lower. This indicates that canopy cover condition in Kemuning Forest is still suitable for arboreal nocturnal mammals, especially the Javan Slow Loris.

Finally, alongside biotic factors, the presence of the Javan Slow Loris in Kemuning Forest is also influenced by abiotic factors. The slope is a part of the structural component that limits the quality of the habitat (Bailey 1984). Environment characteristics formed by slopes affect habitat quality. The Javan Slow Loris in Kemuning Forest tends to choose locations with steeper slopes as this allegedly relates to the activities of what farmers are cultivating on the land. The area with steep slopes tends to be less attractive for farmers to manage intensively. Research reported that steep slopes are one of the important management constraints due to mechanization difficulties and low soil fertility in agriculture areas with varied topography (Marini et al. 2009), and is characterized by high labour requirements (MacDonald et al. 2000). This means that the steep terrain gives less human disturbance pressure to the presence of Javan Slow Loris in the study area. In conclusion, the steep slope area in Kemuning Forest correlates with fewer disturbances by human activity since this area is categorized as having poor land condition by farmers for intensive coffee plantation.

Resource selection by the Javan Slow Loris in Kemuning Forest

Logistic regression result showed that the Javan Slow Loris in Kemuning Forest used microhabitat resources selectively. Habitat variables such as canopy cover and slope have influences on the presence of this species in Kemuning Forest. Therefore, these microhabitat variables in Kemuning Forest form a resource selection function for the presence of the Javan Slow Loris. Dense canopy cover becomes one of the essential limiting factors for the presence of Javan slow Loris in Kemuning Forest. Manly et al. (2002) stated that the main factor of resource selection by an animal is uneven resource distribution along the forest area. Therefore, the habitat variables used by the Javan Slow Loris vary within Kemuning Forest.

The comparison of habitat characteristics data between used and available plots showed significant differences on four variables. The result of logistic regression analysis, however, showed differences in which there were only two microhabitat variables that had a significant influence on the opportunity of resource selection function by the Javan Slow Loris in Kemuning Forest. Those variables are crown coverage on tree stage and slope. Canopy cover and slope contribute a significant effect on the opportunity of microhabitat selection as well as in the comparison of habitat characteristics data between used and available plots. The exp. (ß) value of canopy cover and slope mean that the higher the canopy coverage and the steeper slope, the higher the chance of probability of the presence of the Javan Slow Loris in the study area.

The limitation of this study is the small sample size of the presence data of the animal included in the data analysis. The slow loris is not only nocturnal but is also a small, cryptic, and arboreal species (Nekaris et al. 2014). Therefore, it is difficult to observe the presence of this animal and predict the numbers of the population. The locations within the study area where coffee plants are far from the road and settlement areas have a tendency to be less maintained. The detections of Javan Slow Loris were disrupted by the existence of these dense and irregular coffee plantations. A combination of night surveys and the use of camera traps installed in tree canopies are expected to increase the sample size of this study. In addition, observation of nocturnal animals such as the Javan Slow Loris requires certain skills where observers are used to conducting night survey activities. Ideally, in doing so, this increases the sample size and therefore results in a stronger model within this data analysis.

Despite the fact that this study presents a small sample size, it is capable of representing an overview of the microhabitat needs of the Javan Slow Loris population in Kemuning Forest. To maintain the sustainability of the species population in the area in the long term, it is essential to maintain the existence of vegetation with dense and connected canopy coverage characteristics within the forest. To maintain a suitable habitat, conservation efforts such as habitat management must be directed towards the locations that are truly favoured by the species, considering that the Kemuning Forest is a production forest surrounded by a non-natural forest area.

The results of this study indicate three key factors to improve conservation efforts and management strategies of the Javan Slow Loris. Firstly, the characteristics of Javan Slow Loris habitat in the Kemuning Forest are secondary lowland tropical rainforest with dense canopy cover, located in steep slopes, with low-level habitat disturbance. Secondly, the species exploits microhabitat resources selectively. Habitat factors that influence the probability of resource selection by the species are canopy cover and slope. Finally, canopy cover and slope have a strong influence on the presence of the species and formed a resource selection function in Kemuning Forest.

Therefore, in conclusion, to preserve the Javan Slow Loris population in the Kemuning Forest, it is important to maintain the existing vegetation with a dense canopy cover that is connected to each other. In addition, it is also important to maintain a low level of human disturbance and to manage how the human activities within Kemuning Forest area have the least impact on the presence of the Javan Slow Loris.

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Bahasa Indonesia Abstract: Faktor kehilangan/berkurangnya dan fragmentasi habitat yang terjadi di Pulau Jawa memberikan dampak negatif terhadap satwa endemik kukang Jawa (*Nycticebus javanicus*). Kukang Jawa adalah satwa primata nokturnal endemik di Pulau Jawa yang saat ini tergolong dalam kategori kritis. Hasil penelitian menunjukan bahwa kurang dari 9 % areal hutan alam yang masih tersisa di Pulau Jawa. Salah satu hutan dataran rendah yang tersisa adalah hutan Kemuning di Temanggung Jawa Tengah. Penelitian ini bertujuan untuk mengetahui seleksi habitat oleh kukang Jawa dan faktor-faktor habitat yang menentukan kehadirannya pada skala micro-site. Variabel habitat yang diukur adalah luas bidang dasar pohon, konektivitas pohon, penutupan tajuk pada tingkat pohon, kemiringan lahan, ketinggian tempat, dan jarak dari sungai. Analisis data yang digunakan adalah regresi logistik, likelihood ratio test, dan Akaike Information Criterion (AIC) dengan prosedur backward elimination. Kami juga melakukan observasi dan wawancara kepada masyarakat untuk mengumpulkan data tentang kondisi lingkungan dan gangguan akibat faktor keberadaan manusia. Hasil penelitian ini menunjukan bahwa kukang Jawa melakukan seleksi habitat pada skala mikro. Faktor habitat yang memengaruhi seleksi sumber daya oleh kukang Jawa adalah tutupan tajuk pohon, dan kemiringan lahan. Habitat karakteristik yang disukai oleh kukang Jawa di hutan Kemuning adalah hutan tropis dataran rendah dengan tutupan tajuk yang rapat dan berada pada kemiringan lahan yang curam dengan sedikit tingkat gangguan. Meskipun penelitian ini menggunakan ukuran sampel yang sedikit, diharapkan bahwa hasil dari penelitian ini dapat digunakan sebagai informasi awal untuk manajemen habitat dan manajemen populasi kukang Jawa di hutan Kemuning sebagai acuan dalam usaha-usaha konservasi dan desain strategi pengelolaan.

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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

April 2019 | Vol. 11 | No. 6 | Pages: 13631–13814
Date of Publication: 26 April 2019 (Online & Print)
DOI: 10.11609/jott.2019.11.6.13631-13814

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