BUKTI KORESPONDENSI
PADA JURNAL INTERNASIONAL *PRIMATE CONSERVATION*

DAFTAR ISI

Daftar Lampiran

BUKTI KORESPONDENSI
PADA JURNAL INTERNASIONAL *PRIMATE CONSERVATION*

Proses 1. Pertama Kali Mengirimkan Naskah Ke Jurnal Primate Conservation (Melalui alamat Email)

arylands@globalwildlife.org

Aktif

11 dari 11

Article of Research Kotak Masuk ×

TOTO SUPARTONO <toto.supartono@uniku.ac.id> 8 Jan 2020, 14.53
kepada arylands

Dear Anthony B. Rylands

Here, we submit an article of research conducted on the Island of Java, Indonesia. The species studied was girzzled leaf monkey (Presbytis comata). endemic to the western part of Java Island. Research and publication of the species is limited. We hope this article can be published in the Primate Conservation Journal. Thanks.

Regards
Toto

Satu lampiran • Dipindai dengan Gmail

Toto Supartono_C...

Draft Naskah yang pertama kali dikirim disajikan pada Lampiran 1

Proses 2. Balasan Konfirmasi bahwa Artikel Sudah Sampai Ke Pengelola Jurnal

arylands@globalwildlife.org

Aktif

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Anthony Rylands <arylands@globalwildlife.org> Rab, 8 Jan 2020, 21.55
kepada saya

Inggris > Indonesia Terjemahkan pesan Nonaktifkan untuk: Inggris ×

Dear Dr Supartano,

I have received your submission to the IUCN SSC Primate Specialist Group journal *Primate Conservation*: Controlling Factors of Grizzled Leaf Monkey (*Presbytis comata*) Population Density in a Production Forest in Kuningan District, West Java, Indonesia.

Thank you,

We will be in touch.

Sincerely
Anthony B. Rylands
Editor *Primate Conservation*

Primate Conservation Director
Global Wildlife Conservation

c/o WeWork Chinatown

Proses 3. Balasan dari Pengelola Jurnal Bahwa Artikel telah Selesai di Review

arylands@globalwildlife.org

Aktif

KUNINGAN T

10 dari 11

Primate Conservation: Supartano et al Presbytis comata Kotak Masuk ×

Anthony Rylands <arylands@globalwildlife.org> Min, 12 Jan 2020, 01.03

kepada saya

Inggris > Indonesia Terjemahkan pesan Nonaktifkan untuk: Inggris ×

Dear Dr Toto,

Well, Professor Vincent Nijman was kind enough to review the manuscript in record time!!
I attach here your text with comment boxes and his general comments. Pending the revisions that they suggest, we would be happy to publish your article in the IUCN SSC Primate Specialist Group journal "Primate Conservation".

Please go through his comments, corrections, and suggestions carefully and adjust your text accordingly. One important aspect that he pointed out is that there is new literature that you are not citing. I am attaching here an article (2017) that he sent me, and please use that to get you bibliographic revision up to date.

If you do not agree with Prof. Vincent or are otherwise unable to comply with his requests or suggestions, please explain why. Please indicate your replies/compliance or otherwise on the reviewers' documents so that I can check them, and please highlight any changes to the text. I will return it to Professor Nijman for a second review.

Please remember to check that all the references you cite are in the bibliography and vice versa. Please make sure that your reference list at the end follows the style for "Primate Conservation."

Once we agree on your revised text, I will go through it, and edit it to polish the English and put it into the house style of the journal. I will then send it off for layout and send you the page proofs to check.

Please acknowledge receipt of this e-mail and let me know when you think you will be able to send me the revised text.

Please note that if I dod not hear from within 90 days, I will consider the article to have been withdrawn. If it is not possible for you to submit a revision within this time, please just contact me.

Best wishes,

Anthony

Anthony B. Rylands
Russell A. Mittermeier
Editors – Primate Conservation

Primate Conservation Director
Global Wildlife Conservation

Draft Naskah yang sudah berisi komentar dari reviewer disajikan pada Lampiran 2 dan Lembar Komentar dari Reviewer disajikan pada Lampiran 3.

Porses 4. Penyampaikan Kembali Naskah Yang Sudah Direvisi Ke Pengelola Jurnal

arylands@globalwildlife.org

Aktif

KUNINGAN T

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TOTO SUPARTONO <toto.supartono@uniku.ac.id> Rab, 25 Mar 2020, 11.20

kepada Anthony

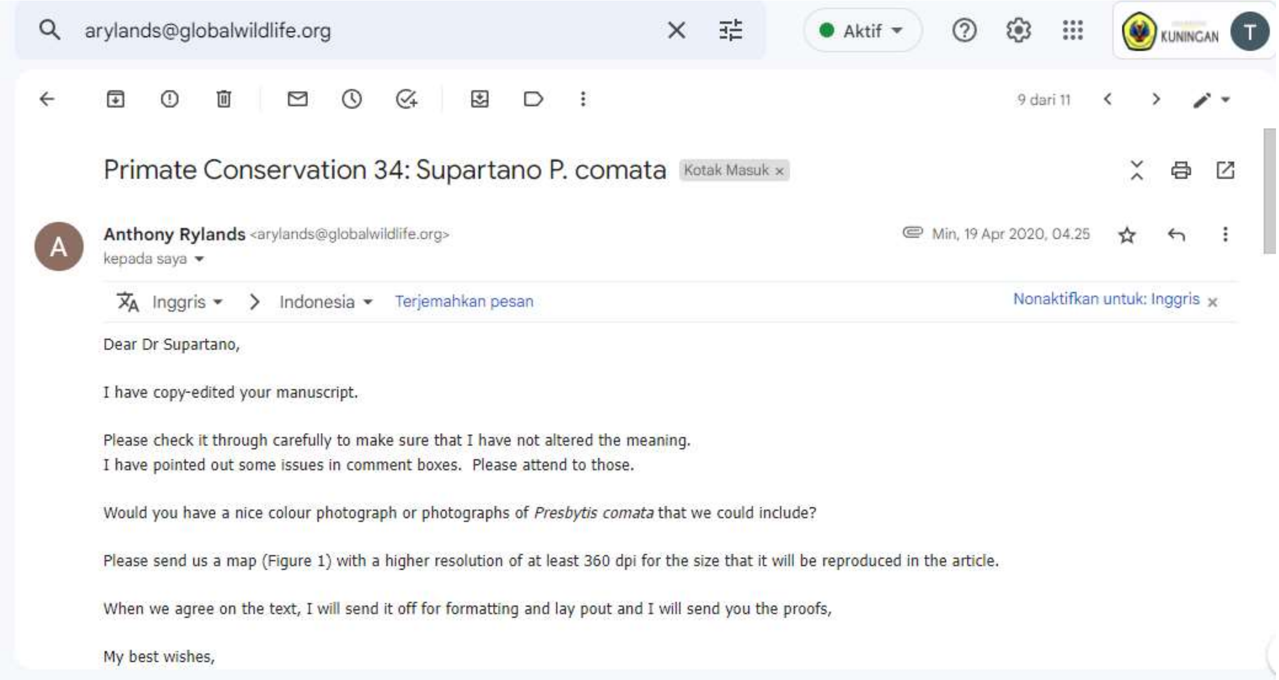
Dear Mr. Anthony B. Rylands
First, I apologize for the delay in sending corrections to this manuscript because many tasks in the field and in the office must be completed. Next, I thank Mr. Anthony B. Rylands for the opportunity given to improve this manuscript. I also say many thanks to Prof. Nijman who was kind enough to correct and provide input on the manuscript.
Hereby, I submit: 1) the manuscript I have repaired in accordance with the advice of the reviewer; 2) a list of responses to comments from reviewers. I hope this manuscript is worthy of publication in the Primate Conservation journal and awaits further information. Thanks.

Regards

Toto Supartono

Naskah Hasil Revisi disajikan pada Lampiran 4 dan Respon Atas Komentar Reviewer Disajikan Pada Lampiran 5.

Proses 5. Pemberitahuan Dari Pengelola Jurnal Bahwa Naskah sudah di Copy Edit oleh Editor



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Aktif

KUNINGAN

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Primate Conservation 34: Supartano P. comata Kotak Masuk

Anthony Rylands <arylands@globalwildlife.org> Min, 19 Apr 2020, 04.25

kepada saya

Inggris > Indonesia Terjemahkan pesan Nonaktifkan untuk: Inggris

Dear Dr Supartano,

I have copy-edited your manuscript.

Please check it through carefully to make sure that I have not altered the meaning.
I have pointed out some issues in comment boxes. Please attend to those.

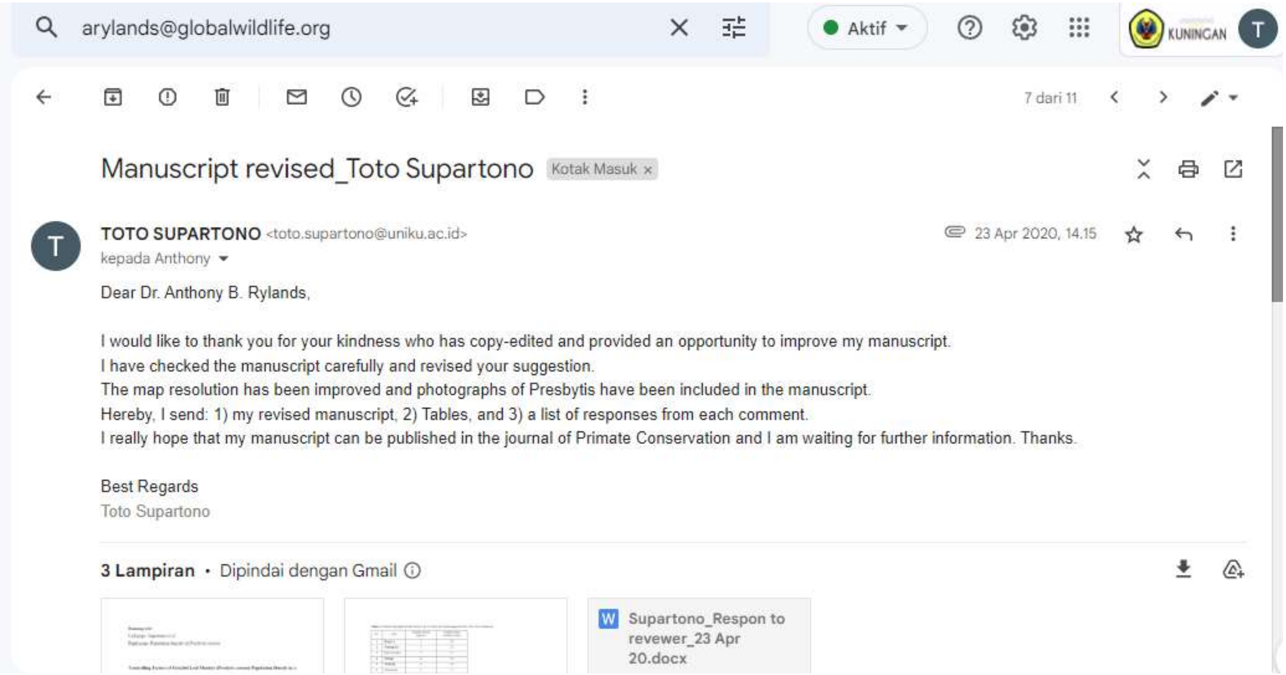
Would you have a nice colour photograph or photographs of *Presbytis comata* that we could include?

Please send us a map (Figure 1) with a higher resolution of at least 360 dpi for the size that it will be reproduced in the article.

When we agree on the text, I will send it off for formatting and lay pout and I will send you the proofs,

My best wishes,

Proses 6. Penyampaian Kembali Bahwa Permintaan Perbaikan dari Editor Sudah Dilaksanakan



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Aktif

KUNINGAN

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Manuscript revised_Toto Supartono Kotak Masuk

TOTO SUPARTONO <toto.supartono@uniku.ac.id> 23 Apr 2020, 14.15

kepada Anthony

Dear Dr. Anthony B. Rylands,

I would like to thank you for your kindness who has copy-edited and provided an opportunity to improve my manuscript.
I have checked the manuscript carefully and revised your suggestion.
The map resolution has been improved and photographs of Presbytis have been included in the manuscript.
Hereby, I send: 1) my revised manuscript, 2) Tables, and 3) a list of responses from each comment.
I really hope that my manuscript can be published in the journal of Primate Conservation and I am waiting for further information. Thanks.

Best Regards
Toto Supartono

3 Lampiran • Dipindai dengan Gmail

Supartono_Respon to revewer_23 Apr 20.docx

Respon terhadap komentar dari editor disajikan pada Lampiran 6.

Proses 7. Pemberitahuan Bahwa Naskah Akan Segera dilaout

arylands@globalwildlife.org

Aktif

KUNINGAN

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Primate Conservation 34: Supartono et al . Presbytis comata Kotak Masuk

Anthony Rylands <arylands@globalwildlife.org> Rab, 29 Apr 2020, 07.52

kepada saya

Inggris > Indonesia Terjemahkan pesan Nonaktifkan untuk: Inggris

Dear Dr. Supartono.

I have sent your article off for layout. The next step: I will send you the page proofs for review.

My best wishes, and I hope you and your family are safe in these troubling times.

Anthony Rylands

Anthony B. Rylands
Primate Conservation Director
Global Wildlife Conservation

c/o WeWork Chinatown

Proses 8. Pemberitahuan Bahwa Proses Naskah Agak Terhambat Karena Adanya Covid-19

arylands@globalwildlife.org

Aktif

KUNINGAN

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Anthony Rylands <arylands@globalwildlife.org> Jum, 22 Mei 2020, 21.01

kepada saya

Inggris > Indonesia Terjemahkan pesan Nonaktifkan untuk: Inggris

Dear Dr Supartano

We are waiting to have the proofs made up.
The person who does the layout is still on CoVID lockdown in New York (unable to go to the office in the university but we are hopeful that soon he will be able to get back to work.
As soon as we get them, I will go through them for corrections and adjustments and then send them to you.
Sorry about the delay.

Anthony B. Rylands
Primate Conservation Director
Global Wildlife Conservation

c/o WeWork Chinatown
718 7th St NW, Washington, DC 20001
E-mail: arylands@globalwildlife.org

Proses 9. Permintaan Untuk Mengecek Ulang Naskah

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Aktif

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Primate Conservation 34: Supartono et al. P. comata Kotak Masuk

Anthony Rylands <arylands@globalwildlife.org> Sen, 25 Mei 2020, 06.55
kepada saya

Inggris > Indonesia Terjemahkan pesan Nonaktifkan untuk: Inggris

PROOFS. *PRIMATE CONSERVATION.*

Article: **Controlling Factors of Grizzled Leaf Monkey (*Presbytis comata*) Population Density in a Production Forest in Kuningan District, West Java, Indonesia**
Authors: Toto Supartono, Lilik Budi Prasetyo, Agus Hikmat, Agus Priyono Kartono

Dear Dr Supartono,

Please find attached the page proof.

Please read it through carefully and let me know of any corrections or adjustments needed.

You can use the comments and highlighting tools on the pdf, or send the corrections needed in a separate document (page, column, paragraph, line).

Please note that all you have to do is inform me of the corrections. You do not have to make them. I will also copy edit the proof.

Please let me know that you have received this, and return the proof, as soon as possible, to:

Anthony B. Rylands
Editor – *Primate Conservation*
Deputy Chair – IUCN SSC Primate Specialist Group

Primate Conservation Director
Global Wildlife Conservation
E-mail: arylands@globalwildlife.org

IUCN SSC Primate Specialist Group
http://www.primate-sg.org/

Naskah yang sudah dikoreksi disajikan pada Lampiran 7.

Proses 10. Balasan Ke Pengelola Jurnal Bahwa Naskah Sudah Selesai Dicek Ulang

arylands@globalwildlife.org

Aktif

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TOTO SUPARTONO <toto.supartono@uniku.ac.id> Rab, 27 Mei 2020, 09.32
kepada Anthony

Dear Dr Anthony B. Rylands
I hereby submit my manuscript (attached). I have read the manuscript carefully and convey a little correction which is presented directly in pdf. I am waiting for the next information. I pray that you and your family stay healthy. Thank you for your kindness.

Greetings

Toto Supartono

Satu lampiran • Dipindai dengan Gmail

34 Supartono SD...

Proses 11. Pemberitahuan dari Editor Bahwa Naskah Sudah Diterbitkan pada Nomor Isu 34

arylands@globalwildlife.org

Aktif

KUNINGAN T

2 dari 11

Primate Conservation 34: Supartono - Presbytis comata Kotak Masuk ×

Anthony Rylands <arylands@globalwildlife.org>   Rab, 18 Nov 2020, 02.42
kepada saya

Inggris > Indonesia Terjemahkan pesan   Nonaktifkan untuk: Inggris ×

Dear Toto,

I have closed issue number 34 of Primate Conservation and your article **"Controlling Factors of Grizzled Leaf Monkey (*Presbytis comata*) Population Density in a Production Forest in Kuningan District, West Java, Indonesia**" now has page numbers: *Primate Conservation* 2020 (34): 153-155.

http://www.primate-sg.org/storage/pdf/PC34_Supartono_et_al_Presbytis_comata_W_Java.pdf

My best wishes

Anthony

Anthony B. Rylands
Primate Conservation Director
Global Wildlife Conservation

Controlling Factors of Grizzled Leaf Monkey (*Presbytis comata*) Population Density in a Production Forest in Kuningan District, West Java, Indonesia

Toto Supartono[1], Lilik Budi Prasetyo[2], Agus Hikmat[2], Agus Priyono Kartono[2]

1. Department of Forestry, Faculty of Forestry, Kuningan University, Jln. Tjut Nyak Dhien, Cijoho, 45513, Kuningan District, Indonesia.

2. Department of Forest Resources Conservation and Ecotourism, Faculty of Forestry, IPB University, Bogor, 16680, Indonesia

Abstract

Land use changes and deforestations have been occurred in Indonesia at an alarming rate resulted in habitat loss of wildlife. In this study, we propose that production forest could be used as an alternative site to conserve animal population. The information about population density and its influencing factors were important to population conservation, however there was limited research on the population of grizzled leaf monkey. This study aimed at estimating grizzled leaf monkey population density in production forest, identify the controlling factors, and discuss the conservation implications. The survey was conducted in 23 forest areas to collect data of grizzled leaf monkey population density, density of other primates, the number of food tree species, tree and food density, and stump density. The study also measured research site distance to the nearest road, the nearest settlement, and to other natural forest area. Descriptive statistic and multiple linear regression was used in data analysis. This study found that grizzled leaf monkey population density was 34.63 ± 19.07 individuals km^{-2} and positively correlated with the number of food tree species, but negatively related to the density of tree stumps which was an indicator of habitat disturbance due to timber extraction. These results indicate that the diversity of food tree species and logging activities should be taken into consideration in formulating conservation strategies of grizzled leaf monkey population in production forests.

Keywords: grizzled leaf monkey, *Presbytis comata*, population density, food trees, conservation, production forest.

Introduction

Natural forest ecosystems continues to decline and becomes one of the major issues in biodiversity conservation. Therefore, production forests generally in the form of plantations and other cultivation area can be utilized in the conservation of the species (Brockerhoff *et al*. 2008; Lindenmayer *et al*. 2009; Rayadin and Saitoh 2009; Salek *et al*. 2010; van Halder *et al*. 2011; Fashing *et al*. 2012). It will reduce dependency to conservation area of species population preservation. Many of the production forests had become location of wildlife population dispersion (Marsden *et al*. 2001; Luckett *et al*. 2004; Pawson *et al*. 2008; Lindenmayer *et al*. 2009; van Halder *et al*. 2011) including protected and endangered animals (for example, *Hylobates agilis*, *H. lar*, dan *M. nemestrina*: Nasi *et al*. 2008; orangutan: Rayadin and Spehar 2015). Some species utilized the forest as a source of food, rest, sleep, corridors, and home range (Ganzhorn 1985; Ganzhorn 1987; Rayadin and Saitoh 2009; Yamada and Muroyama 2010; Henzi *et al*. 2011; Campbell-Smith *et al*. 2012).

Grizzled leaf monkey was one of the primates species which has limited natural distribution only at the western part of Java Island (Kool 1992), protected (PP No. 7/1999), endangered (IUCN 2015), and prioritized by the government for conservation (Regulation No.P.57/Menhut-II/2008). Distribution of the monkey restricted to mountain forest ecosystems (Nijman 1997), but the main habitat was lowland natural forests and hills (Hoogerworf 1970; Nijman 1997). Conversion of forest into other uses such as agricultural areas leaving approximately only 4% of the remaining natural habitat (MacKinnon 1987) mostly in mountain forest ecosystems. Therefore, the population conservation was prioritized in mountain forests which was generally a conservation areas (Supriatna *et al*. 1994). In addition, the population of grizzled leaf monkey can be found also in lowland forests, including production forests (Sujatnika 1991). Therefore, population conservation on this forest ecosystem is also important.

Density was one of population parameters required on conservation program. Density studies of grizzled leaf monkey have been conducted by previous researchers mostly in the conservation areas (Ruhiyat 1983; Melisch and Dirgayusa 1996; Tobing 1999; Heriyanto and Iskandar 2004; Kartono *et al*. 2009), while there is lack of research in production forests. Furthermore, information about the controlling factors that determine the population density was also important in developing effective conservation strategies of population (Chapman *et al*. 2004; Mbora and Meikle 2004; Agetsuma *et al*. 2015). Previous studies on controlling factors of controlling other primates have been done by numerous researchers (Ross and Srivastava 1994; Wich *et al*. 2004; Just *et al*. 2006; Lehman *et al*. 2006; Reinartz *et al*. 2006; Arroyo-Rodriguez *et al*. 2007; Fuller *et al*. 2009; Grow *et al*. 2013; Ray *et al*. 2015), but there is no study on grizzled leaf monkeye. Study about grizzled leaf monkey was limited to research done by Kartono *et al*. (2009). The study was only carried out on protected areas (National Park of Mount Ciremai) covered dominantly by natural forest. The study was only testing the effect of the density of some tree species on the population of grizzled leaf monkey. The limited studies resulted in insufficient knowledge on factors affecting the monkey population density.

Many factors affect population density of primates. In this study we examined characteristics of the vegetation as food resources (Wieczkowski 2004; Anderson *et al*. 2007; Cristobal-Azkarate and Arroyo-Rodriguez 2007; Mammides *et al*. 2008; Pozo-Montuy *et al*. 2011; Kankam and Sicote 2013), spatial attribute (Estrada and Coates-Estrada 1996; Arroyo-Rodriguez *et al*. 2008; Pozo-Montuy *et al*. 2011), and habitat disturbance (Chapman *et al*. 2007). This study aimed at (1) estimating grizzled leaf monkey population density, (2) identifying the factors that determine the population density the monkey in production forests, and (3) disccusing the conservation implications. We hypothesized that the number of tree species, food trees and food density would positively effect on grizzled leaf monkey population density, while the density of other primates which occupy the same habitat would have negative effect. We also predicted that population density would decrease with a) increasing distance from research sites to larger natural forests, and b) decreasing distance from research site to the nearest road. Forest disturbance indicated by tree stump density was also expected to negatively affect population density. This information on the factors that influence the population density could help grizzled leaf monkey conservation in production forests.

Methodology

Study area

We conducted this research at 23 forest areas of Bukit Pembarisan forest groups in Kuningan District (108°23' - 108°47' east longitude and 6°47' - 7°12' south latitude), West Java Province, Indonesia. Annual rainfall of this district is 1000-4000 mm $year^{-1}$ (Bappeda Kuningan District 2015). Our research site is a production forest with a total area of 452.57 km^2. Land cover at this research site was a combination of mixed farms, plantations and natural forest remnants (Prasetyo *et al*. 2012). Mixed farms is managed by community, located on private land and planted with commercial tree species and fruit-bearing crops, such as sengon (*Paraserianthes falcataria*), mahogany (*Swietenia mahagoni*), jabon (*Anthocepalus cadamba*), teak (*Tectona grandis*), mango (*Mangifera indica*), bitter bean (*Parkia speciosa*), coconut (*Cocos nucifera*), jackfruit (*Artocarpus heterophyllus*), and melinjo (*Gnetum gnemon*) (Prasetyo *et al*. 2012). Planted forests were production forests managed by PT. Pehutani under Kuningan Forest Management Units (FMU) located on state land, and generally establish monoculture stand such as teak or pine forest. The forest remnants were also part of the production forest scattered randomly and allocated as local protected area due to its steep and very steep topography. The remnants of natural forests is classified as lowland forest ecosystem and situated in hills area, experienced disturbance in the past, and generally bordered or surrounded by mixed farms and plantations.

Grizzled leaf monkey population

This study began with visiting villages that have forest area to obtain information from local community (Chi *et al*. 2014) about the presence or absence of grizzled leaf monkey populations in forest areas within the administrative area of the village. We conducted the population density survey based on the secondary information obtained from the community. Line transect method were employed (Greenwood and Robinson 2006; Martins 2005), which has been widely used on primates population density estimation (Brugiere and Fleury 2000) due to higher accuracy compare to other methods (Hoing *et al*. 2013).

Data collection of the monkey population started early in the morning around 06:00 until noon around 12.00 local time. It was obtained by walking slowly on a path that already existed or made by our team (Estrada and Coates-Estrada 1996). Speed of observation varies as it was influenced by topography, tree and shrub density. Transect directions were deflected when we found ravines or cliffs that were impossible to pass, but directed toward initial target.

The total length of line transect at each location varied from 5 to 6 km measured using hipchain. We recorded number animal in each group when encountered group of grizzled leaf monkeys (Eisenberg *et al*. 1981). We also obtained the distance between observerto the first seen individual using Rangefinder (Nikon forestry). Activities, tree species observation coordinates and the angle (θ) of the monkey group to observer position and transect direction were also recorded. Observation coordinate was obtained using

GPSmap 60CSx. Observation time varied and considered finish when each of individual in the group has been identified accurately or observers have agreed to the estimate (Anderson *et al*. 2007; Pozo-Montuy *et al*. 2011). Data collection was assisted by two trained field assistants to count and detect the monkey group member.

Other primates

Other primates species found in the site were *M. fascicularis* and *T. auratus*. Data were collected using the same method and site during the grizzled monkey study. The existance of these species is considered influencing size of grizzled leaf monkey population because *T. auratus* was leaf eater (Kool 1993) and *M. fascicularis* was also leaf eater when its main food getting scarce. During data collection, we tied plastic rope on the branch or pole every 100 m as sign of data collection point for habitat attribute.

Habitat attributes

Habitat characteristics that were considered to affect the primate population density including the number of tree species (Ross and Srivastava 1994; Kankam and Sicote 2013), the number of food trees species (Cristobal-Azkarate and Arroyo-Rodriguez 2007; Mammides *et al*. 2008; Pozo-Montuy *et al*. 2011), tree density (Ross and Srivastava 1994; Wieczkowski 2004), and food tree density (Anderson *et al*. 2007). Habitat data were collected after population data were gathered line transect (Soerianegara and Indrawan 2005). Sample plots were established every 100 m along transect of grizzled leaf monkey population. Size of each plot was 20 m x 20 m (Kusmana and Istomo 1995). We recorded data of species name and diameter at breast height for each tree with diameter ≥ 10 cm (Onderdonk and Chapman 2000). Trees with diameter ≥ 10 cm were considered strong and big enough for primates to be used in feeding activity (Worman and Chapman 2006). This study did not collect data of undergrowth and trees with diameters less than 10 cm due to arboreal characteristic of grizzled leaf monkey (Ruhiyat 1983; Gunawan *et al*. 2008). Unkown tree species found in sample plots was identified at Bogoriense Herbarium of Indonesian Institute of Sciences. Food trees species of grizzled leaf monkey were identified by three approachments namely study of previous research (for example, Ruhiyat 1983, Melisch and Dirgayusa 1996, Farida and Harun 2000), interview with local community who often found grizzled leaf monkey groups, and direct observation.

Spatial attribute

This study also includes spatial attributes which predicted to influence primate population density. The variables were research site distance to nearest natural forest (Estrada and Coates-Estrada 1996; Pozo-Montuy *et al*. 2011), research site distance to the nearest settlement and road (Arroyo-Rodriguez *et al*. 2008). The distance of each location to the larger natural forest edge was obtained by measuring average distance from coordinates of the initial point of line transect and projecting the distance using Google Earth Map. Similar method was used to obtain the distance from each location to the earest road and settlement.

Habitat disturbance attribute

Habitat disturbance attribute collected in the research was tree stump density as an indicator of disturbance level and habitat destruction through logging (Wood and Gillman 1998). Logging was expected to negatively affect the density of primates (Chapman *et al*. 2007). Data were collected in parallel with vegetation data in the sample plot. Stump were recorded limited to undecayed one.

Data Analysis

Estimation of population density in this study was calculated using mean of all line transect. We attempt to obtain a general overview and estimate the population density of each site to identify the controlling factors of the population density. The estimation of entire research site begun with group density estimation (Martins 2005) using the following formula:

$$D = \text{detected group number} / 2(\text{ESW}) \,.\, L$$

where D = grizzled leaf monkey group density (group/ km^2), ESW = effective wide (m), and L = total line transect (km). ESW value obtained using Distance software 5.0. The population density was obtained by multiplying the density of the group with an average size of groups from entire research sites (Martins 2005; Fashing *et al*. 2012). Estimations of population density in each transect was also using the same formula using the number of groups in each transect, transect length, and the average size of groups of each location. We rarely found more than one group in one transect, thus we used one ESW value for transects. The same technique was used to estimate langur and long tail monkey population density which were going to be used as free variable on each location.

Habitat characteristics were analyzed by descriptive (mean and standard deviation). Langur and long tail monkey population, after the density was known, was also followed by a descriptive analysis. Selection of variables identified as a good predictor for grizzled leaf monkey population density was done through three stages. The first stage was to analyze the data distribution using Kolmogorov-Smirnov test. Data is normally distributed if $p > 0.05$. We then run a Pearson correlation test among all independent variables at $p \leq 0.05$ (Anzures-Dadda and Manson 2007; Arroyo-Rodriguez *et al*. 2008). In multiple regression, the number of tree species were excluded from the analysis due to significant correlation number of food tree species ($r = 0.90$; $p < 0.001$). Total tree density was excluded due to its correlation to food tree density ($r = 0.58$; $p = 0.009$) and tree stump density ($r = 0.46$; $p = 0.050$). The research site distance to nearest settlement also excluded for the strong correlation with distance to the nearest road and forest area ($r = 0.94$; $p < 0.001$, $r = 0.46$; $p = 0.048$) respectively. Furthermore, to identify habitat components significantly influence population density, multiple linear regression through stepwise method was used (Mbora and Meikle 2004) using SPSS 21 software. The significance level used was $(\alpha) \leq 0.05$. Contribution rate of combined variables to population density can be seen through R^2 value.

Results

Population density

We conducted this study in 23 forest divisions with total line transect of 122.23 km. The total population of grizzled leaf monkey from the line transects and its nearby area were 486 originated from 65 groups. Thus, we estimate there were 7.48 ± 5.35 monkey per group. However, population density in this study was calculated based on 41 groups found in the line transects. We used Distance ver. 5.0 to estimate group density of 4.63 ±2.80 km^{-2}. This study estimates the population density of 34.63 ± 19.07 individuals km^{-2} calculated by multiplying mean of group size and group density. No monkey was observed on 4 forest plots at our research site. Therefore, we excluded this plots and analysis was conducted based on 19 forests division data. During this study we re-interviewed respondents who is familiar with the plot history to obtain further data on existence of the monkey in these 4 plots. Respondents were confident that the plots were habitat of this monkey. Nevertheless, we decided to exclude those plots. Effective plot wide to estimate the population density was 36.16 m with a total line transect of 100.3 km. Mean of populations density was 45±42.03 (mean±SD) and it ranged from 7.68-184.36 individuals km^{-2}.

Habitat characteristic

Data of habitat characteristic is developed from 19 forest divisions divided into 1003 plots. Data of all measured variables were normally distributed. Descriptive statistic and Kolmogorov-Smirnov test of the 7 variables used to estimate population density are presented in Table 1.

Table 1 Descriptive statistic and Kolmogorov-Smirnov test of habitat and other factors influencing grizzled leaf monkey in production forest of Kuningan District

Variable	N	mean	SD	Kolmogorov-Smirnov test	
				Z	p
Langur population density (individuals km^{-2})	19	144.16	103.51	0.517	0.952
Long tail monkey density (individuals km^{-2})	19	40.47	74.67	1.281	0.075
Number of food tree species (species ha^{-1})	19	22.21	4.25	0.717	0.683
Food tree density (individuals ha^{-1})	19	158.24	43.88	0.798	0.548
Stump density (individuals ha^{-1})	19	2.10	3.19	1.126	0.159
Research site distance to the nearest road (km)	19	0.59	0.38	0.699	0.713
Research site distance to the nearest forest area (km)	19	12.57	6.42	0.549	0.924

Factors controlling population density

This research found two out of seven variables were significantly related to grizzled leaf monkey density in this production forest which are number of food tree species and stump density. The effect of each variable were contradictory (Table 2). Number of food tree species displayed significant positive relationship with the monkey population while increasing stump density were significantly decrease the monkey population. Increasing of stump number indicates an increasing of forest disturbance. Both variables are responsible to explain 40% variability of the monkey population density (R^2 = 0.40; F = 5.33;

p = 0.017). However there were no significant relationship (p >0.05) between the monkey population density and other measured variables including food tree density, langur population density, distance of research site to the nearest road and forest area. Thus, we suggest that number of food tree species and stump density are good predictors to estimate the monkey population density.

Table 2 Variables significantly related to *Presbytis comata* population density

Model	Constant (SE)	T	p
Constant	-60.92 (43.28)	-1.408	0.178
Number of food tree species (species ha^{-1})	5.32 (1.94)	2.739	0.015
Stump density (ind ha^{-1})	-5.79 (2.59)	-2.237	0.040

Discussion

The study of evaluating grizzled leaf monkey population density in a production forest is limited. Previous studies have been conducted mainly in conservation forest. Thus, we suggest that it will contribute to a better estimation of grizzled leaf monkey population in Indonesia. We recorded 486 animals in this study and suggest that it will increase our current estimate of the monkey total population by 21.3 % considering latest data estimate of 2285 individuals (Supriatna *et al*. 1994). Our results also provide information on controlling factors effecting the monkey population. It confirms that the monkey population was influenced by food availability and habitat disturbance due to human activities. Forests areas with high variability of food tree species have higher population density as it can provide sufficient food to support the monkey population. Population density was decreasing as the response to increase logging or timber harvesting.

Comparison of this study to other similar research has been difficult due to no literature available on population estimated from production forest. Thus, we compared this study with previous studies conducted in conservation forests. Our study found similar population density of grizzled leaf monkey in Situ Patenggang Nature Reserve (Ruhiyat 1983). However, our results were ninefold and triple than that in Ujung Kulon National Park and Gunung Ciremai National Park respectively (Heriyanto and Iskandar 2004; Kartono *et al*. 2009). Sufficient information were not available to explain the difference estimate and variability. We suggest that the effect of different methods applied and quality of the habitats affected this findings. Nevertheless, it is important to recognize that this study provided the first evidence on the significant contribution of production forest to support the monkey population. Grizzled leaf monkey has been listed by IUCN as endangered species for almost 28 years since 1988. Identification of new potential habitats and its population, for example by this study site, will be imperative to the monkey conservation.

Lowland forests have been identified as grizzled leaf monkey main habitat (Hoogerworf 1970), most likely due to the variability of food tree species available. Hence, high variability of tree species in natural forest resulted in high variability of food sources and habitat quality (Li 2004; Arroyo-Rodriguez and Mandujano 2006). Similarly, positive correlation between number species of food tree and the monkey population in our study showed the important of food sources variabilities to support the survival of the monkey. Previous studies on other primates population density were also in agreement with our findings including *Procolobus gordonorum* population in Udzungwa Mountain National Park (Rovero and Struhsaker 2007), *Colobus guereza* and *Cercopithecus mitis* population in Kakamega forest, Kenya (Mammides *et al*. 2008), *P. kirkii* in Zanzibar (Siex and Struhsaker 1999), and *P. rubicunda* di Sepilok nature reserve, Malaysia (Davies *et al*. 1988). Cristobal-Azkarate dan Arroyo-Rodriguez (2007) reported that howler monkey (*Alouatta palliata*) population depends on number species of food tree. In Cabeza del Toro and the Santuario Nacional Cordillera de Colan, Peru, ocuppancy probabilty of Peruvian night monkey *Aotus miconax* has a positif correlation with diversity of the vegetation (Campbell *et al*. 2019). Based on the results of our research and other previous studies, this shows that enrichment of tree species needs to be done in production forests.

Population density is likely determined by the variability of food tree species to support primate nutrition (Cristobal-Azkarate *et al*. 2005) including carbohidrate, protein, fat, vitamin and mineral (Chapman *et al*. 2012). Main nutrition of primate from sub family colobine is obtained from leaf (Ruhiyat 1983; Kirkpatrick 1999; Wasserman and Chapman 2003). However, each tree species has different leaf nutrition and energy content (Farida and Harun 2000; Nelson *et al*. 2000; Wasserman and Chapman 2003; Hockings *et al*. 2009). For example, *Albizia falcataria* has higher protein (26.34%) and energy (5.17 kkal gram^{-1}) compare to *Ficus padana* with protein content of 14.64% and energy of 4.69 kkal gram^{-1}. In addition, *A. falcataria*has lower fat (0.96%) than that of *F. padana* (2.93%) (Farida and Harun 2000). Grizzled leaf monkey also consumes fruits (Ruhiyat 1983) which usually have different fruiting season among tree species (Keonig *et al*. 1997; Hockings *et al*. 2009) and variability of nutrient content (Milton

2003; Wasserman and Chapman 2003). Therefore, primate consumes only specific food unlikely to fulfill its nutrient need. Primate requires sufficient and balance nutrition to support reproduction, grow, development and survival (Keonig *et al*. 1997; Felton *et al*. 2009; Chapman *et al*. 2012). It is important for primates to eat different food tree species (Cristobal-Azkarate *et al*. 2005; Chaves *et al*. 2011). We suggest that the above conditions can explain why the monkey were found at forest with high variability of food tree species.

In addition, our study also identify the significant influence of stump density on the monkey population. Forest disturbance has been detected as one of factors controlling the monkey population. The remaining stump left in sites after timber harvesting can determine site level disturbance. The monkey populations were lower in sites with high stumps density as the negative effect of logging. This result is in agreement with previous studies in other locations including *Galago demidovii*, *G. inustus*, and *Perodictus potto* in Kibale forest (Weisenseel *et al*. 1993), chimpanzee in western Equatorial of Africa (Morgan and Sanz 2007), *Procolobus pennantii* and *Colobus guereza* in western Uganda (Chapman *et al*. 2007). Logging has been responsible to declining of *Lophocebus albigena* group density of Kibale Natinal Park in Uganda (Chapman *et al*. 2000). Negative effect of logging also observed on Congo's gorillas population due to available access of poachers through the logging tract (Haurez *et al*. 2013). Our research site is located in a production forest where logging activity is a must. It is important to further examine effective logging intensity to obtain economic benefit and at the same time ensure sustainability of the monkey population.

Similar to other primates, grizzled leaf monkey is also categorized as shy animal (Ruhiyat 1983) that avoid interaction with human (Tobing 1999). During logging activities, workers and the sound of logging machine (chainsaw) will create a noisy environment that trigger the monkey to move to other locations. As a result, the monkey population density will be lower than that in less human disturbance areas. Li (2004) reported decreasing population of snub-nosed monkey (*Rhinopithecus roxellana*) in Shennongjia nature reserve in China due to human activity.

Our hypothesis was food tree density will positively correlate to the monkey population in accordance with the studies on *Procolobus rufomitratus, Pan troglodytes, Alouatta pigra* (Balcomb *et al*. 2000; Mbora and Meikle 2004; Pozo-Montuy *et al*. 2011). In addition, our preliminary hypothesis was *T. auratus* and *M. fascicularis* density will negatively influence grizzled leaf monkey due to consuming similar diet (Kool

1992; Kool 1993; Yeager 1996). However, results of this study were not in agreement with hypothesis. No response of food tree density on the monkey population implies that food availability was yet to be the limiting factor (Yeager and Kirkpatrick 1998). We suspect that the monkey has flexibility on food sources in accordance with general characteristic of *Colobus angolensis palliatus* species (Anderson *et al*. 2007) under the subfamily colobinae (Rowe 1996).

Asian colobine can consume young and old leaf as a source of diet (Yeager and Kirkpatrick 1998). Leaf is considered as relatively stable and abundance food sources (Chapman 1990). Therefore, food need of Asian colobine including grizzled leaf monkey is still bellow environment carrying capacity (Yeager and Kirkpatrick 1998). Thus no competition observed between the monkey and *T. auratus* dan *M. fascicularis* to fulfill food need. We propose the above reason behind no relationship between the monkey and other primates.

We measured also the relationship of the monkey population and plot distance to the nearest road. We assumed that road construction also represent the nearest community settlement. Arroyo-Rodriguez *et al*. (2008) reported that road displayed significant positive correlation with *Alouatta palliata mexicana* population. However, our results are not agreement with this study. We suggest that the different response was due to higher intensity of human activity in this study than that in our research site. We also suggest that the different species studied contribute also to this difference. No response of grizzled leaf monkey population to nearest road indicated that this variable is yet to be the monkey threat. Similar to study on *C. angolensis palliatus* population in Kenya beach forest (Anderson *et al*. 2007). We presume that vehicle and human activities in our research site is still under the monkey tolerance and they have been adapting to the condition. Inconsistent monkey population has also contributed to this finding as proposed by Anderson *et al*. (2007).

Estrada and Coates-Estrada (1996) reported primate distance to nearest forest ecosystem will influence spot where the population can be found. To measure this effect we tested the influence of our research site distance to nearest forest area of Gunung Subang forest (GS). We found the opposite result compare to previous studies of Cristobal-Azkarate *et al*. (2005) and Arroyo-Rodriguez *et al*. (2008) on *A. palliata mexicana* population in Los Tuxtlas Mexico. Our results were also in contrary to Pozo-Montuy *et al*. (2011) study that found the farther distance from nearest forest the lower *A. pigra* population. We propose that the different was due different species characteristics and site specific condition, however, the actual reason is still unidentified. We suspected that the length wise position of our research site toward the GS forest with agricultural and settlement in both side created no corridor for the monkey movement. We understand that corridor is an important aspect to allow animal migration including primates (Anzures-Dadda and Manson 2007). There was also a pine forest and road construction located between our research site and GS forest. However, we urge that further research is needed to identify the controlling factors of the monkey population in relation to nearest forest distance.

This research was conducted in one forest landscape in one district. Further campaigns in other districts of the monkey habitat need to be examined. This is to establish a robust estimate of population density and the controlling factors since our results only explained less than 50% of population variability. Further research should consider a larger study site, straight observation line rather using available track in the site, expanding environmental variables including food source from lianas (Ruhiyat 1983) and protein to fiber of food tree species.

In Indonesia, the government also owns a plantation company called PT Perhutani. Conservation approach can be tested at those plantations by mixing main species with food tree species including pulai (*Alstonia scholaris*), saninten (*Castanopsis argentea*), kondang (*Ficus glomerata*), walen (*Ficus ribes*), beunying (*Ficus* sp.), kareumbi (*Omalanthus populneus*), pasang (*Quercus* sp.), and peutag (*Syzygium lineatum*) (Ruhiyat 1983). In mixed farms, in addition to planting food tree species, increasing the proportion and number of multipurpose tree using non-timber forest product species can be planted including cloves, coconut, mango, mangosteen, melinjo, rambutan, nutmeg, and guava can seen as. Nonetheless, population management of grizzled monkey population in production forests including mixed farms require more in-depth study that involve relevant stakeholders to sustain both conservation and economic benefits.

Variability of food tree species and level of forest disturbance due to logging activity were the controlling factors of grizzled leaf monkey population. Conservation efforts of the monkey in the future should consider these environmental variables. Balance proportion of commercial tree species and at the same time planting sufficient food tree species will contribute to sustainability of this effort while at the same time ensure the economic benefit of company. We suggest that this approach can be replicated in other conservation activities in particular for production forest area. However, further research is needed involving bigger area and more environmental variables.

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Lampiran 2. Draft Naskah yang sudah berisi komentar dari reviewer

Controlling Factors of Grizzled Leaf Monkey (*Presbytis comata*) Population Density in a Production Forest in Kuningan District, West Java, Indonesia

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Abstract

Land use changes and deforestations have been occurred in Indonesia at an alarming rate resulted in habitat loss of wildlife. In this study, we propose that production forest could be used as an alternative site to conserve animal population. The information about population density and its influencing factors were important to population conservation, however there was limited research on the population of grizzled leaf monkey. This study aimed at estimating grizzled leaf monkey population density in production forest, identify the controlling factors, and discuss the conservation implications. The survey was conducted in 23 forest areas to collect data of grizzled leaf monkey population density, density of other primates, the number of food tree species, tree and food density, and stump density. The study also measured research site distance to the nearest road, the nearest settlement, and to other natural forest area. Descriptive statistic and multiple linear regression was used in data analysis. This study found that grizzled leaf monkey population density was 34.63 ± 19.07 individuals km^{-2} and positively correlated with the number of food tree species, but negatively related to the density of tree stumps which was an indicator of habitat disturbance due to timber extraction. These results indicate that the diversity of food tree species and logging activities should be taken into consideration in formulating conservation strategies of grizzled leaf monkey population in production forests.

Keywords*:* grizzled leaf monkey, *Presbytis comata*, population density, food trees, conservation, production forest.

Introduction

Natural forest ecosystems continues to decline and becomes one of the major issues in biodiversity conservation. Therefore, production forests generally in the form of plantations and other cultivation area can be utilized in the conservation of the species (Brockerhoff *et al*. 2008; Lindenmayer *et al*. 2009; Rayadin and Saitoh 2009; Salek *et al*. 2010; van Halder *et al*. 2011; Fashing *et al*. 2012). It will reduce dependency to conservation area of species population preservation. Many of the production forests had become location of wildlife population dispersion (Marsden *et al*. 2001; Luckett *et al*. 2004; Pawson *et al*. 2008; Lindenmayer *et al*. 2009; van Halder *et al*. 2011) including protected and endangered animals (for example, *Hylobates agilis*, *H. lar*, dan *M. nemestrina*: Nasi *et al*. 2008; orangutan: Rayadin and Spehar 2015). Some species utilized the forest as a source of food, rest, sleep, corridors, and home range (Ganzhorn 1985; Ganzhorn 1987; Rayadin and Saitoh 2009; Yamada and Muroyama 2010; Henzi *et al*. 2011; Campbell-Smith *et al*. 2012).

Grizzled leaf monkey was one of the primates species which has limited natural distribution only at the western part of Java Island (Kool 1992), protected (PP No. 7/1999), Eendangered (IUCN 2015 – change to Nijman and Richardson 2008, see references), and prioritized by the government for conservation (Regulation No.P.57/Menhut-II/2008). Distribution of the monkey restricted to mountain forest ecosystems (Nijman 1997), but the main habitat was lowland natural forests and hills (Hoogerworf 1970; Nijman 1997). Conversion of forest into other uses such as agricultural areas leaving approximately only 4% of the remaining natural habitat (MacKinnon 1987) mostly in mountain forest ecosystems. Therefore, the population conservation was prioritized in mountain forests which was generally a conservation areas (Supriatna *et al.* 1994). In addition, the population of grizzled leaf monkey can be found also in lowland forests, including production forests (Sujatnika 1991). Therefore, population conservation on this forest ecosystem is also important.

Density was one of population parameters required on conservation program. Density studies of grizzled leaf monkey have been conducted by previous researchers mostly in the conservation areas (Ruhiyat 1983; Melisch and Dirgayusa 1996; Tobing 1999; Heriyanto and Iskandar 2004; Kartono *et al.* 2009), while there is lack of research in production forests. Furthermore, information about the controlling factors that determine the population density was also important in developing effective conservation strategies of population (Chapman *et al*. 2004; Mbora and Meikle 2004; Agetsuma *et al*. 2015). Previous

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studies on controlling factors of controlling other primates have been done by numerous researchers (Ross and Srivastava 1994; Wich *et al*. 2004; Just *et al*. 2006; Lehman *et al*. 2006; Reinartz *et al*. 2006; Arroyo-Rodriguez *et al*. 2007; Fuller *et al*. 2009; Grow *et al*. 2013; Ray *et al*. 2015), but there is no study on grizzled leaf monkeyse. Study about grizzled leaf monkey was limited to research done by Kartono *et al*. (2009). The study was only carried out on protected areas (National Park of Mount Ciremai) covered dominantly by natural forest. The study was only testing the effect of the density of some tree species on the population of grizzled leaf monkey. The limited studies resulted in insufficient knowledge on factors affecting the monkey population density.

Many factors affect population density of primates. In this study we examined characteristics of the vegetation as food resources (Wieczkowski 2004; Anderson *et al*. 2007; Cristobal-Azkarate and Arroyo-Rodriguez 2007; Mammides *et al*. 2008; Pozo-Montuy *et al*. 2011; Kankam and Sicote 2013), spatial attribute (Estrada and Coates-Estrada 1996; Arroyo-Rodriguez *et al*. 2008; Pozo-Montuy *et al*. 2011), and habitat disturbance (Chapman *et al*. 2007). This study aimed at (1) estimating grizzled leaf monkey population density, (2) identifying the factors that determine the population density the monkey in production forests, and (3) disccusing the conservation implications. We hypothesized that the number of tree species, food trees and food density would positively effect on grizzled leaf monkey population density, while the density of other primates which occupy the same habitat would have negative effect. We also predicted that population density would decrease with a) increasing distance from research sites to larger natural forests, and b) decreasing distance from research site to the nearest road. Forest disturbance indicated by tree stump density was also expected to negatively affect population density. This information on the factors that influence the population density could help grizzled leaf monkey conservation in production forests.

Methodology

Study area

We conducted this research at 23 forest areas of Bukit Pembarisan forest groups in Kuningan District (108°23' - 108°47' east longitude and 6°47' - 7°12' south latitude), West Java Province, Indonesia. Annual rainfall of this district is 1000-4000 mm year^{-1} (Bappeda Kuningan District 2015). Our research site is a production forest with a total area of 452.57 km^2. Land cover at this research site was a combination of

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mixed farms, plantations and natural forest remnants (Prasetyo *et al*. 2012). Mixed farms is managed by community, located on private land and planted with commercial tree species and fruit-bearing crops, such as sengon (*Paraserianthes falcataria*), mahogany (*Swietenia mahagoni*), jabon (*Anthocepalus cadamba*), teak (*Tectona grandis*), mango (*Mangifera indica*), bitter bean (*Parkia speciosa*), coconut (*Cocos nucifera*), jackfruit (*Artocarpus heterophyllus*), and melinjo (*Gnetum gnemon*) (Prasetyo *et al*. 2012). Planted forests were production forests managed by PT. Pehutani under Kuningan Forest Management Units (FMU) located on state land, and generally establish monoculture stand such as teak or pine forest. The forest remnants were also part of the production forest scattered randomly and allocated as local protected area due to its steep and very steep topography. The remnants of natural forests is classified as lowland forest ecosystem and situated in hills area, experienced disturbance in the past, and generally bordered or surrounded by mixed farms and plantations.

Grizzled leaf monkey population

This study began with visiting villages that have forest area to obtain information from local community (Chi *et al*. 2014) about the presence or absence of grizzled leaf monkey populations in forest areas within the administrative area of the village. We conducted the population density survey based on the secondary information obtained from the community. Line transect method were employed (Greenwood and Robinson 2006; Martins 2005), which has been widely used on primates population density estimation (Brugiere and Fleury 2000) due to higher accuracy compare to other methods (Hoing *et al*. 2013).

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Data collection of the monkey population started early in the morning around 06:00 until noon around 12.00 local time. It was obtained by walking slowly on a path that already existed or made by our team (Estrada and Coates-Estrada 1996). Speed of observation varies as it was influenced by topography, tree and shrub density. Transect directions were deflected when we found ravines or cliffs that were impossible to pass, but directed toward initial target.

The total length of line transect at each location varied from 5 to 6 km measured using hipchain. We recorded number animal in each group when encountered group of grizzled leaf monkeys (Eisenberg *et al*. 1981). We also obtained the distance between observerto the first seen individual using Rangefinder (Nikon forestry). Activities, tree species observation coordinates and the angle (θ) of the monkey group to observer position and transect direction were also recorded. Observation coordinate was obtained using *GPSmap 60CSx.* Observation time varied and considered finish when each of individual in the group has been identified accurately or observers have agreed to the estimate (Anderson *et al*. 2007; Pozo-Montuy *et al*. 2011). Data collection was assisted by two trained field assistants to count and detect the monkey group member.

Other primates

Other primates species found in the site were long-tailed macaques *M. fascicularis* and ebony langurs *T. auratus*. Data were collected using the same method and site during the grizzled monkey study. The existance of these species is considered influencing size of grizzled leaf monkey population because *T. auratus* was leaf eater (Kool 1993) and *M. fascicularis* was also leaf eater when its main food getting scarce. During data collection, we tied plastic rope on the branch or pole every 100 m as sign of data collection point for habitat attribute.

Habitat attributes

Habitat characteristics that were considered to affect the primate population density including the number of tree species (Ross and Srivastava 1994; Kankam and Sicote 2013), the number of food trees species (Cristobal-Azkarate and Arroyo-Rodriguez 2007; Mammides *et al*. 2008; Pozo-Montuy *et al*. 2011), tree density (Ross and Srivastava 1994; Wieczkowski 2004), and food tree density (Anderson *et al*. 2007). Habitat data were collected after population data were gathered line transect (Soerianegara and Indrawan 2005). Sample plots were established every 100 m along transect of grizzled leaf monkey population. Size of each plot was 20 m x 20 m (Kusmana and Istomo 1995). We recorded data of species name and diameter at breast height for each tree with diameter ≥ 10 cm (Onderdonk and Chapman 2000). Trees with diameter ≥ 10 cm were considered strong and big enough for primates to be used in feeding activity (Worman and Chapman 2006). This study did not collect data of undergrowth and trees with diameters less than 10 cm due to arboreal characteristic of grizzled leaf monkey (Ruhiyat 1983; Gunawan *et al*. 2008). Unkown tree species found in sample plots was identified at Bogoriense Herbarium of Indonesian Institute of Sciences. Food trees species of grizzled leaf monkey were identified by three approachments namely study of previous research (for example, Ruhiyat 1983, Melisch and Dirgayusa

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1996, Farida and Harun 2000), interview with local community who often found grizzled leaf monkey groups, and direct observation.

Commented [VN14]: Two of these studies are in montane forest and Melish and Dirgayusa only observed six species that the leaf monkeys fed on.

Spatial attributes

This study also includes spatial attributes which predicted to influence primate population density. The variables were research site distance to nearest natural forest (Estrada and Coates-Estrada 1996; Pozo-Montuy *et al*. 2011), research site distance to the nearest settlement and road (Arroyo-Rodriguez *et al*. 2008). The distance of each location to the larger natural forest edge was obtained by measuring average distance from coordinates of the initial point of line transect and projecting the distance using Google Earth Map. Similar method was used to obtain the distance from each location to the earest road and settlement.

Habitat disturbance attribute

Habitat disturbance attribute collected in the research was tree stump density as an indicator of disturbance level and habitat destruction through logging (Wood and Gillman 1998). Logging was expected to negatively affect the density of primates (Chapman *et al*. 2007). Data were collected in parallel with vegetation data in the sample plot. Stump were recorded limited to undecayed one.

Data Analysis

Estimation of population density in this study was calculated using mean of all line transect. We attempt to obtain a general overview and estimate the population density of each site to identify the controlling factors of the population density. The estimation of entire research site begun with group density estimation (Martins 2005) using the following formula:

$$D = \text{detected group number} / 2(\text{ESW}) \cdot L$$

where D = grizzled leaf monkey group density (group/ km^2), ESW = effective wide (m), and L = total line transect (km). ESW value obtained using Distance software 5.0. The population density was obtained by multiplying the density of the group with an average size of groups from entire research sites (Martins 2005; Fashing *et al*. 2012). Estimations of population density in each transect was also using the same formula using the number of groups in each transect, transect length, and the average size of groups of each location. We rarely found more than one group in one transect, thus we used one ESW value for transects. The same technique was used to estimate ebony langur and long tail ~~monkey~~ macaque population density which were going to be used as free variable on each location.

Habitat characteristics were analyzed by descriptive (mean and standard deviation). Ebony l~~L~~angur and long tail ~~monkey~~ macaque population, after the density was known, was also followed by a descriptive analysis. Selection of variables identified as a good predictor for grizzled leaf monkey population density was done through three stages. The first stage was to analyze the data distribution using Kolmogorov-Smirnov test. Data is normally distributed if $p > 0.05$. We then run a Pearson correlation test among all independent variables at $p \leq 0.05$ (Anzures-Dadda and Manson 2007; Arroyo-Rodriguez *et al.* 2008). In multiple regression, the number of tree species were excluded from the analysis due to significant correlation number of food tree species ($r = 0.90$; $p < 0.001$). Total tree density was excluded due to its correlation to food tree density ($r = 0.58$; $p = 0.009$) and tree stump density ($r = 0.46$; $p = 0.050$). The research site distance to nearest settlement also excluded for the strong correlation with distance to the nearest road and forest area ($r = 0.94$; $p < 0.001$, $r = 0.46$; $p = 0.048$) respectively. Furthermore, to identify habitat components significantly influence population density, multiple linear regression through stepwise method was used (Mbora and Meikle 2004) using SPSS 21 software. The significance level used was $(\alpha) \leq 0.05$. Contribution rate of combined variables to population density can be seen through R^2 value.

Results

Population density

We conducted this study in 23 forest divisions with total line transect of 122.23 km. The total population of grizzled leaf monkey from the line transects and its nearby area were 486 originated from 65 groups. Thus, we estimate there were 7.48 ± 5.35 leaf monkeys per group. However, population density in this study was calculated based on 41 groups found in the line transects. We used Distance ver. 5.0 to estimate group density of 4.63 ±2.80 km^{-2}. This study estimates the population density of 34.63 ± 19.07 individuals km^{-2} calculated by multiplying mean of group size and group density. No monkey was observed on 4 forest plots at our research site. Therefore, we excluded this plots and analysis was conducted based on 19 forests division data. During this study we re-interviewed respondents who is familiar with the plot history to obtain further data on existence of the monkey in these 4 plots.

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Respondents were confident that the plots were habitat of this monkey. Nevertheless, we decided to exclude those plots. Effective plot wide to estimate the population density was 36.16 m with a total line transect of 100.3 km. Mean of populations density was 45±42.03 (mean±SD) and it ranged from 7.68-184.36 individuals km^{-2}.

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Habitat characteristic

Data of habitat characteristic is developed from 19 forest divisions divided into 1003 plots. Data of all measured variables were normally distributed. Descriptive statistic and Kolmogorov-Smirnov test of the 7 variables used to estimate population density are presented in Table 1.

Table 1 Descriptive statistic and Kolmogorov-Smirnov test of habitat and other factors influencing grizzled leaf monkey in production forest of Kuningan District (all based on 19 forest divisions)

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Variable	mean	SD	Kolmogorov-Smirnov test	
			Z	p
Ebony l~~L~~angur population density (individuals km^{-2})	144.16	103.51	0.517	0.952
Long tailed macaque ~~monkey~~ density (individuals km^{-2})	40.47	74.67	1.281	0.075
Number of food tree species (species ha^{-1})	22.21	4.25	0.717	0.683
Food tree density (individuals ha^{-1})	158.24	43.88	0.798	0.548
Stump density (individuals ha^{-1})	2.10	3.19	1.126	0.159
Research site distance to the nearest road (km)	0.59	0.38	0.699	0.713
Research site distance to the nearest forest area (km)	12.57	6.42	0.549	0.924

Factors controlling population density

This research found two out of seven variables were significantly related to grizzled leaf monkey density in this production forest which are number of food tree species and stump density. The effect of each variable were contradictory (Table 2). Number of food tree species displayed significant positive relationship with the monkey population while increasing stump density were significantly decrease the monkey population. Increasing of stump number indicates an increasing of forest disturbance. Both variables are responsible to explain 40% variability of the monkey population density ($R^2 = 0.40$; $F = 5.33$; $p = 0.017$). However there were no significant relationship ($p > 0.05$) between the monkey population density and other measured variables including food tree density, langur population density, distance of research site to the nearest road and forest area. Thus, we suggest that number of food tree species and stump density are good predictors to estimate the monkey population density.

Table 2 Variables significantly related to *Presbytis comata* population density

Model	Constant (SE)	T	p
Constant	-60.92 (43.28)	-1.408	0.178
Number of food tree species (species ha^{-1})	5.32 (1.94)	2.739	0.015
Stump density (ind ha^{-1})	-5.79 (2.59)	-2.237	0.040

Discussion

The study of evaluating grizzled leaf monkey population density in a production forest is limited. Previous studies have been conducted mainly in conservation forest. Thus, we suggest that it will contribute to a better estimation of grizzled leaf monkey population in Indonesia. We recorded 486 animals in this study and suggest that it will increase our current estimate of the monkey total population by 21.3 % considering latest data estimate of 2285 individuals (Supriatna *et al*. 1994). Our results also provide information on controlling factors effecting the monkey population. It confirms that the monkey population was influenced by food availability and habitat disturbance due to human activities. Forests areas with high variability of food tree species have higher population density as it can provide sufficient food to support the monkey population. Population density was decreasing as the response to increase logging or timber harvesting.

Commented [VN20]: A more recent estimate for the number of grizzled leaf monkey population on Java (based on 'just' 11 areas where the species was studied) is 1,760 – 2,360 groups; with a group size of just over seven individuals, that translates to between 13,000 and 17,000 individuals. Suggest to rewrite this.

Comparison of this study to other similar research has been difficult due to no literature available on population estimated from production forest. Thus, we compared this study with previous studies conducted in conservation forests. Our study found similar population density of grizzled leaf monkey in

Situ Patenggang Nature Reserve (Ruhiyat 1983). However, our results were ninefold and triple than that in Ujung Kulon National Park and Gunung Ciremai National Park respectively (Heriyanto and Iskandar 2004; Kartono *et al*. 2009). Sufficient information were not available to explain the difference estimate and variability. We suggest that the effect of different methods applied and quality of the habitats affected this findings. Nevertheless, it is important to recognize that this study provided the first evidence on the significant contribution of production forest to support the monkey population. Grizzled leaf monkey has been listed by IUCN as Eendangered species for almost 28 years since 1988. Identification of new potential habitats and its population, for example by this study site, will be imperative to the monkey conservation.

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Lowland forests have been identified as grizzled leaf monkey main habitat (Hoogerworf 1970), most likely due to the variability of food tree species available. Hence, high variability of tree species in natural forest resulted in high variability of food sources and habitat quality (Li 2004; Arroyo-Rodriguez and Mandujano 2006). Similarly, positive correlation between number species of food tree and the monkey population in our study showed the important of food sources variabilities to support the survival of the monkey. Previous studies on other primates population density were also in agreement with our findings including *Procolobus gordonorum* population in Udzungwa Mountain National Park (Rovero and Struhsaker 2007), *Colobus guereza* and *Cercopithecus mitis* population in Kakamega forest, Kenya (Mammides *et al*. 2008), *P. kirkii* in Zanzibar (Siex and Struhsaker 1999), and *P. rubicunda* di Sepilok nature reserve, Malaysia (Davies *et al*. 1988). Cristobal-Azkarate dan Arroyo-Rodriguez (2007) reported that howler monkey (*Alouatta palliata*) population depends on number species of food tree. In Cabeza del Toro and the Santuario Nacional Cordillera de Colan, Peru, ocuppancy probabilty of Peruvian night monkey *Aotus miconax* has a positif correlation with diversity of the vegetation (Campbell *et al*. 2019). Based on the results of our research and other previous studies, this shows that enrichment of tree species needs to be done in production forests.

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Population density is likely determined by the variability of food tree species to support primate nutrition (Cristobal-Azkarate *et al*. 2005) including carbohidrate, protein, fat, vitamin and mineral (Chapman *et al*. 2012). Main nutrition of primate from sub family colobine is obtained from leaf (Ruhiyat 1983; Kirkpatrick 1999; Wasserman and Chapman 2003). However, each tree species has different leaf nutrition and energy content (Farida and Harun 2000; Nelson *et al*. 2000; Wasserman and Chapman 2003;

Hockings *et al*. 2009). For example, *Albizia falcataria* has higher protein (26.34%) and energy (5.17 kkal $gram^{-1}$) compare to *Ficus padana* with protein content of 14.64% and energy of 4.69 kkal $gram^{-1}$. In addition, *A. falcataria*has lower fat (0.96%) than that of *F. padana* (2.93%) (Farida and Harun 2000). Grizzled leaf monkey also consumes fruits (Ruhiyat 1983) which usually have different fruiting season among tree species (Keonig *et al*. 1997; Hockings *et al*. 2009) and variability of nutrient content (Milton 2003; Wasserman and Chapman 2003). Therefore, primate consumes only specific food unlikely to fulfill its nutrient need. Primate requires sufficient and balance nutrition to support reproduction, grow, development and survival (Keonig *et al*. 1997; Felton *et al*. 2009; Chapman *et al*. 2012). It is important for primates to eat different food tree species (Cristobal-Azkarate *et al*. 2005; Chaves *et al*. 2011). We suggest that the above conditions can explain why the monkey were found at forest with high variability of food tree species.

In addition, our study also identify the significant influence of stump density on the monkey population. Forest disturbance has been detected as one of factors controlling the monkey population. The remaining stump left in sites after timber harvesting can determine site level disturbance. The monkey populations were lower in sites with high stumps density as the negative effect of logging. This result is in agreement with previous studies in other locations including *Galago demidovii*, *G. inustus*, and *Perodictus potto* in Kibale forest (Weisenseel *et al*. 1993), chimpanzee in western Equatorial of Africa (Morgan and Sanz 2007), *Procolobus pennantii* and *Colobus guereza* in western Uganda (Chapman *et al*. 2007). Logging has been responsible to declining of *Lophocebus albigena* group density of Kibale Natinal Park in Uganda (Chapman *et al*. 2000). Negative effect of logging also observed on Congo's gorillas population due to available access of poachers through the logging tract (Haurez *et al*. 2013). Our research site is located in a production forest where logging activity is a must. It is important to further examine effective logging intensity to obtain economic benefit and at the same time ensure sustainability of the monkey population.

Similar to other primates, grizzled leaf monkey is also categorized as shy animal (Ruhiyat 1983) that avoid interaction with human (Tobing 1999). During logging activities, workers and the sound of logging machine (chainsaw) will create a noisy environment that trigger the monkey to move to other locations. As a result, the monkey population density will be lower than that in less human disturbance areas. Li (2004) reported decreasing population of snub-nosed monkey (*Rhinopithecus roxellana*) in Shennongjia nature reserve in China due to human activity.

Our hypothesis was food tree density will positively correlate to the monkey population in accordance with the studies on *Procolobus rufomitratus, Pan troglodytes, Alouatta pigra* (Balcomb *et al*. 2000; Mbora and Meikle 2004; Pozo-Montuy *et al*. 2011). In addition, our preliminary hypothesis was *T. auratus* and *M. fascicularis* density will negatively influence grizzled leaf monkey due to consuming similar diet (Kool 1992; Kool 1993; Yeager 1996). However, results of this study were not in agreement with hypothesis. No response of food tree density on the monkey population implies that food availability was yet to be the limiting factor (Yeager and Kirkpatrick 1998). We suspect that the monkey has flexibility on food sources in accordance with general characteristic of *Colobus angolensis palliatus* species (Anderson *et al*. 2007) under the subfamily colobinae (Rowe 1996).

Asian colobine can consume young and old leaf as a source of diet (Yeager and Kirkpatrick 1998). Leaf is considered as relatively stable and abundance food sources (Chapman 1990). Therefore, food need of Asian colobine including grizzled leaf monkey is still bellow environment carrying capacity (Yeager and Kirkpatrick 1998). Thus no competition observed between the monkey and *T. auratus* dan *M. fascicularis* to fulfill food need. We propose the above reason behind no relationship between the monkey and other primates.

We measured also the relationship of the monkey population and plot distance to the nearest road. We assumed that road construction also represent the nearest community settlement. Arroyo-Rodriguez *et al*. (2008) reported that road displayed significant positive correlation with *Alouatta palliata mexicana* population. However, our results are not agreement with this study. We suggest that the different response was due to higher intensity of human activity in this study than that in our research site. We also suggest that the different species studied contribute also to this difference. No response of grizzled leaf monkey population to nearest road indicated that this variable is yet to be the monkey threat. Similar to study on *C. angolensis palliatus* population in Kenya beach forest (Anderson *et al*. 2007). We presume that vehicle and human activities in our research site is still under the monkey tolerance and they have been adapting to the condition. Inconsistent monkey population has also contributed to this finding as proposed by Anderson *et al*. (2007).

Estrada and Coates-Estrada (1996) reported primate distance to nearest forest ecosystem will influence spot where the population can be found. To measure this effect we tested the influence of our research site distance to nearest forest area of Gunung Subang forest (GS). We found the opposite result compare to previous studies of Cristobal-Azkarate *et al*. (2005) and Arroyo-Rodriguez *et al*. (2008) on *A. palliata mexicana* population in Los Tuxtlas Mexico. Our results were also in contrary to Pozo-Montuy *et al*. (2011) study that found the farther distance from nearest forest the lower *A. pigra* population. We propose that the different was due different species characteristics and site specific condition, however, the actual reason is still unidentified. We suspected that the length wise position of our research site toward the GS forest with agricultural and settlement in both side created no corridor for the monkey movement. We understand that corridor is an important aspect to allow animal migration including primates (Anzures-Dadda and Manson 2007). There was also a pine forest and road construction located between our research site and GS forest. However, we urge that further research is needed to identify the controlling factors of the monkey population in relation to nearest forest distance.

This research was conducted in one forest landscape in one district. Further campaigns in other districts of the monkey habitat need to be examined. This is to establish a robust estimate of population density and the controlling factors since our results only explained less than 50% of population variability. Further research should consider a larger study site, straight observation line rather using available track in the site, expanding environmental variables including food source from lianas (Ruhiyat 1983) and protein to fiber of food tree species.

In Indonesia, the government also owns a plantation company called PT Perhutani. Conservation approach can be tested at those plantations by mixing main species with food tree species including pulai (*Alstonia scholaris*), saninten (*Castanopsis argentea*), kondang (*Ficus glomerata*), walen (*Ficus ribes*), beunying (*Ficus* sp.), kareumbi (*Omalanthus populneus*), pasang (*Quercus* sp.), and peutag (*Syzygium lineatum*) (Ruhiyat 1983). In mixed farms, in addition to planting food tree species, increasing the proportion and number of multipurpose tree using non-timber forest product species can be planted including cloves, coconut, mango, mangosteen, melinjo, rambutan, nutmeg, and guava can seen as. Nonetheless, population management of grizzled monkey population in production forests including mixed farms require more in-depth study that involve relevant stakeholders to sustain both conservation and economic benefits.

Variability of food tree species and level of forest disturbance due to logging activity were the controlling factors of grizzled leaf monkey population. Conservation efforts of the monkey in the future should consider these environmental variables. Balance proportion of commercial tree species and at the same time planting sufficient food tree species will contribute to sustainability of this effort while at the same time ensure the economic benefit of company. We suggest that this approach can be replicated in other conservation activities in particular for production forest area. However, further research is needed involving bigger area and more environmental variables.

Acknowledgment

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Lampiran 3. Lembar Komentar dari Reviewer

Reviewer' assessment.

Controlling Factors of Grizzled Leaf Monkey (*Presbytis comata*) Population Density in a Production Forest in Kuningan District, West Java, Indonesia. Toto Supartono *et al.*

This paper is very interesting and relatively well done, and it is from a lowland forest area which makes it even more interesting (most research has been conducted in the mountains).

1. It needs some help with the English.
2. I recently published a paper (Nijman, V., 2017. Group composition and monandry in grizzled langurs, *Presbytis comata*, on Java. *Folia Primatologica* 88:237-254; attached) where I give an overview of the social organization of the species based on two decades of research. There is lots of information in there on densities, population sizes, group structure, distribution etc. and lots of references to studies that have been conducted on *P. comata*. I would suggest that they read that paper and use the information presented in there to update their paper - now a lot of the work they refer to is very outdated. I have also written a few more papers on the primates of Java (including *P. comata*) and they may be useful for them to read as well -- most of these are open access (they seem to have only read my first 1997 paper).
3. It is good to see that they refer to a lot of research done on primates, but overall the reference list is a bit excessive - I would suggest to cut it in half and then add the ones that actually deal with *P. comata.*
4. I think a list of food plants would be useful - they now based it on three studies, two in montane areas and one in the lowlands but that one only reported five species of plants being consumed so it was not really a dietary study.
5. It would be good if they could add a bit more information on the ebony langurs and the long-tailed macaques they recorded as these are used as predictors for the densities of grizzled leaf monkeys.
6. It would be good if the discussion would focus a bit more on other research that has been conducted on *P. comata* rather than other primates on other continents.
7. Perhaps a figure or a map or even some photographs may be helpful as well as I am sure not all the readers of *Primate Conservation* are familiar with Java or grizzled leaf monkey

Overall I think it has the potential to be a good paper. And please send them my 2017 paper.

Lampiran 4. Naskah Hasil Revisi

Controlling Factors of Grizzled Leaf Monkey (*Presbytis comata*) Population Density in a Production Forest in Kuningan District, West Java, Indonesia

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Abstract

Land use changes and deforestations have been occurred in Indonesia at an alarming rate resulted in habitat loss of wildlife. In this study, we propose that production forest could be used as an alternative site to conserve animal population. The information about population density and its influencing factors were important to population conservation, however there was limited research on the population of grizzled leaf monkey. This study aimed at estimating grizzled leaf monkey population density in production forest, identify the controlling factors, and discuss the conservation implications. The survey was conducted in 19~~23~~ forest areas to collect data of grizzled leaf monkey population density, density of other primates, the number of food tree species, tree and food density, and stump density. The study also measured research site distance to the nearest road, the nearest settlement, and to other natural forest area. Descriptive statistic and multiple linear regression was used in data analysis. This study found that grizzled leaf monkey population density ~~was 34.63 ± 19.07~~ ranges from 36.97 to 54.12 individuals km^{-2} (mean = 44.71 ind. km^{-2}) and positively correlated with the number of food tree species, but negatively related to the density of tree stumps which was an indicator of habitat disturbance due to timber extraction. These results indicate that the diversity of food tree species and logging activities should be taken into consideration in formulating conservation strategies of grizzled leaf monkey population in production forests.

Keywords*:* grizzled leaf monkey, *Presbytis comata*, population density, food trees, conservation, production forest.

Introduction

Natural forest ecosystems continues to decline and becomes one of the major issues in biodiversity conservation. Therefore, production forests generally in the form of plantations and other cultivation area can be utilized in the conservation of the species (Brockerhoff *et al*. 2008; Lindenmayer *et al*. 2009; Rayadin and Saitoh 2009; Salek *et al*. 2010; van Halder *et al*. 2011; Fashing *et al*. 2012). It will reduce dependency to conservation area of species population preservation. Many of the production forests had become location of wildlife population dispersion (Marsden *et al*. 2001; Luckett *et al*. 2004; Pawson *et al*. 2008; Lindenmayer *et al*. 2009; van Halder *et al*. 2011) including protected and endangered animals (for example, *Hylobates agilis*, *H. lar*, dan *M. nemestrina*: Nasi *et al*. 2008; orangutan: Rayadin and Spehar 2015). Some species utilized the forest as a source of food, rest, sleep, corridors, and home range (~~Ganzhorn 1985;~~ Ganzhorn 1987; Rayadin and Saitoh 2009; Yamada and Muroyama 2010; Henzi *et al*. 2011; Campbell-Smith *et al*. 2012).

Grizzled leaf monkey was one of the primates species which has limited natural distribution, from West Java to Mt. Lawu on the border with Est Java ~~only at the western part of Java Island~~ (~~Kool~~ Nijman 2013; Nijman 2017)~~1992~~), protected (Regulation No.P.20/Menlhk/Setjen/Kum.1/6/2018)~~PP No. 7/1999~~), e~~E~~ndangered (Nijman and Richardson 2008)~~IUCN 2015 – change to Nijman and Richardson 2008, see references~~), and prioritized by the government for conservation (Regulation No.P.57/Menhut-II/2008). Distribution of the monkey restricted to mountain forest ecosystems (Nijman 1997), but the main habitat was lowland natural forests and hills (Hoogerworf 1970; Nijman 1997). The remaining forest ecosystems on the island of Java due to land conversion is only 16.39% of total area, which consists of 9.51% as production forests and 6.88% as the combined protection and conservation forest (KLHK 2018); it is almost the same as the number mentioned by Nijman (2013), which is 10% of the Java Island. ~~Conversion of forest into other uses such as agricultural areas leaving approximately only 4% of the remaining natural habitat (MacKinnon 1987) mostly in mountain forest ecosystems~~. Therefore, the population conservation was prioritized in mountain forests which was generally a conservation areas (Supriatna *et al*. 1994). In addition, the population of grizzled leaf monkey can be found also in lowland forests (Nijman and van Balen 1998; Nijman 2017)~~, including production forests (Sujatnika 1991~~). Therefore, population conservation on this forest ecosystem is also important.

Commented [VN1]: This is a paper about food selection in a different species of langur, Trachypithecus auratus, so I suggest to use a different reference. I recently published a wide-ranging overview of the ecology of P. comata – Nijman 2017 – see references

Commented [VN2]: I think that if you read some of the more recent papers, you will find that the MacKinnon etimate is a bit outdated. I would use some more recent references.

Commented [VN3]: Nijman and van Balen (1998) studied them in lowlands; also see the overview paper by Nijman (2017) as it has all the recent large populations listed by altitude.

Commented [VN4]: But Sujatnika studied them in the mountains – and, agreed in Jasinga which is in the lowlands, but there were only very few grizzled leaf monkeys there – one group if I recall correctly.

Density was one of population parameters required on conservation program. Density studies of grizzled leaf monkey have been conducted by previous researchers mostly in the conservation areas (Ruhiyat 1983; Melisch and Dirgayusa 1996; Tobing 1999; Heriyanto and Iskandar 2004; Kartono *et al.* 2009; Nijman 2017), while there is lack of research in production forests. Furthermore, information about the controlling factors that determine the population density was also important in developing effective conservation strategies of population (Chapman *et al.* 2004; Mbora and Meikle 2004; Agetsuma *et al.* 2015). Previous studies on controlling factors of controlling other primates have been done by numerous researchers (Ross and Srivastava 1994; Wich *et al.* 2004; ~~Just *et al.* 2006; Lehman *et al.* 2006; Reinartz *et al.* 2006; Arroyo-Rodriguez *et al.* 2007; Fuller *et al.* 2009; Grow *et al.* 2013;~~ Ray *et al.* 2015), but there is no study on grizzled leaf monkeyse. Study about factors affecting density of grizzled leaf monkey was limited to research done by Kartono *et al.* (2009). The study was only carried out on protected areas (National Park of Mount Ciremai) covered dominantly by natural forest. ~~The study~~Kartono *et al.* was only testing the effect of the density of some tree species on the population of grizzled leaf monkey. The study conducted by Nijman (2017) was relationship between group size and altitude and environmental variables The limited studies resulted in insufficient knowledge on factors affecting the grizzled leaf monkey population density.

Many factors affect population density of primates. In this study we examined characteristics of the vegetation as food resources (~~Wieczkowski 2004; Anderson *et al.* 2007; Cristobal-Azkarate and Arroyo-Rodriguez 2007;~~ Mammides *et al.* 2008; Pozo-Montuy *et al.* 2011; Kankam and Sicote 2013), spatial attribute (Estrada and Coates-Estrada 1996; Arroyo-Rodriguez *et al.* 2008~~; Pozo-Montuy *et al.* 2011~~), and habitat disturbance (Chapman *et al.* 2007). This study aimed at (1) estimating grizzled leaf monkey population density, (2) identifying the factors that determine the population density the monkey in production forests, and (3) disccusing the conservation implications. We hypothesized that the number of tree species, food trees and food density would positively effect on grizzled leaf monkey population density, while the density of other primates which occupy the same habitat would have negative effect. We also predicted that population density would decrease with a) increasing distance from research sites to larger natural forests, and b) decreasing distance from research site to the nearest road. Forest disturbance indicated by tree stump density was also expected to negatively affect population density. This information

Commented [VN5]: Again see Nijman 2017 as there is more information in there.

Commented [VN6]: Whilte I think it is good to refer to a wide range of papers, I think here it would suffice if you were to pick just two or three.

Commented [VN7]: Unclear what you mean – there has been quite a bit more research done on them; perhaps check Nijman 2017 again

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Commented [VN8]: See comment 6

on the factors that influence the population density could help grizzled leaf monkey conservation in production forests.

Methodology

Study area

We conducted this research at 19~~23~~ forest areas of Bukit Pembarisan forest groups in Kuningan District (108°23' - 108°47' east longitude and 6°47' - 7°12' south latitude) (Figure 1), West Java Province, Indonesia. Annual rainfall of this district is 1000-4000 mm year^{-1} (Bappeda Kuningan District 2015). Our research site is a production forest with a total area of 452.57 km^2. Land cover at this research site was a combination of mixed farms, plantations and natural forest remnants (Prasetyo *et al*. 2012). Mixed farms is managed by community, located on private land and planted with commercial tree species and fruit-bearing crops, such as sengon (*Paraserianthes falcataria*), mahogany (*Swietenia mahagoni*), jabon (*Anthocepalus cadamba*), teak (*Tectona grandis*), mango (*Mangifera indica*), bitter bean (*Parkia speciosa*), coconut (*Cocos nucifera*), jackfruit (*Artocarpus heterophyllus*), and melinjo (*Gnetum gnemon*) (Prasetyo *et al*. 2012). Planted forests were production forests managed by PT. Pehutani under Kuningan Forest Management Units (FMU) located on state land, and generally establish monoculture stand such as teak or pine forest. The forest remnants were also part of the production forest scattered randomly and allocated as local protected area due to its steep and very steep topography. The remnants of natural forests is classified as lowland forest ecosystem and situated in hills area, experienced disturbance in the past, and generally bordered or surrounded by mixed farms and plantations.

Grizzled leaf monkey population

This study began with visiting villages that have forest area to obtain information from local community (Chi *et al*. 2014) about the presence or absence of grizzled leaf monkey populations in forest areas within the administrative area of the village. Second step, ~~We~~ we conducted the population density survey in areas or forests based on the secondary information obtained from the community by line transect method. ~~Line transect~~ The method were employed (Greenwood and Robinson 2006; Martins 2005), which has been widely used on primates population density estimation (Brugiere and Fleury 2000) due to higher accuracy compare to other methods (Hoing *et al*. 2013).

Commented [VN9]: This is a wide range – how come?

Commented [VN10]: This is interesting as this suggests the transects (or paths) were not placed in a random or somehow organised manner, but focussed on areas where local people indicated the presence of the leaf monkeys. While I have no real issue with this, this makes it difficult to extrapolate to total population size in the area.

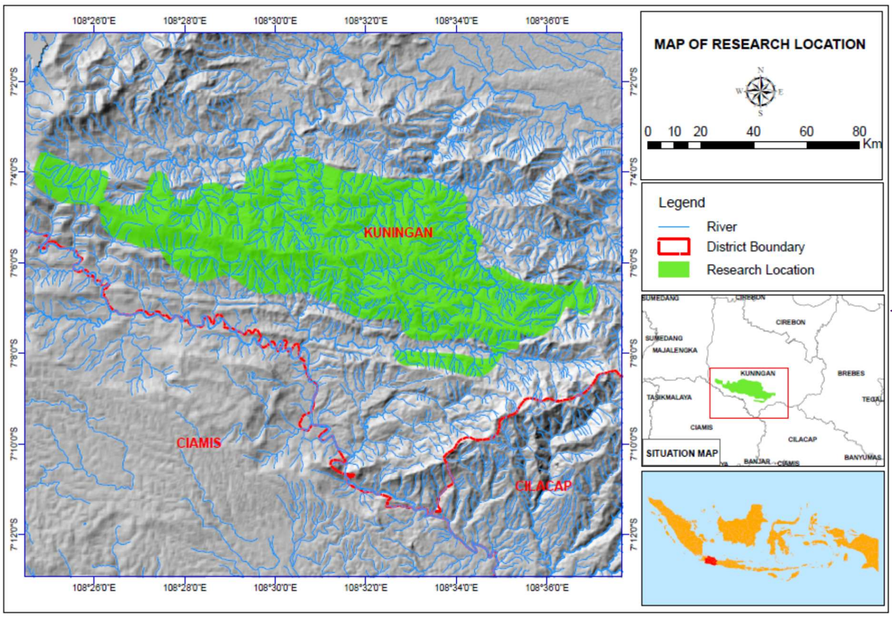

Figure 1. Map of research location of grizzled leaf monkey in Kuningan District, West Java Province

Data collection of the monkey population started early in the morning around 06:00 until noon around 12.00 local time. It was obtained by walking slowly on a path that already existed or made by our team (Estrada and Coates-Estrada 1996), by considering the distance between the lanes and the representation of the area. Speed of observation varies as it was influenced by topography, tree and shrub density. Transect directions were deflected when we found ravines or cliffs that were impossible to pass, but directed toward initial target.

The total length of line transect at each location varied from 5 to 6 km measured using hipchain. We recorded number animal in each group when encountered group of grizzled leaf monkeys (Eisenberg *et al*. 1981). We also obtained the distance between observerto the first seen individual using Rangefinder (Nikon forestry). Activities, tree species observation coordinates and the angle (θ) of the monkey group to observer position and transect direction were also recorded. Observation coordinate was obtained using *GPSmap 60CSx.* Observation time varied and considered finish when each of individual in the group has been identified accurately or observers have agreed to the estimate (Anderson *et al*. 2007; Pozo-Montuy *et*

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al. 2011). Data collection was assisted by two trained field assistants to count and detect the monkey group member.

Other primates

Other primates species found in the site were long-tailed macaques (*Macaca~~.~~ fascicularis*), ~~and~~ ebony langurs (*Trachypithecus~~.~~ auratus*), ~~.~~and slow loris (*Nycticebus javanicus*); while Javan gibbon (*Hylobates moloch*) were never found. For the first two primates, d~~D~~ata were collected using the same method and site during the grizzled monkey study. The existance of these species is considered influencing size of grizzled leaf monkey population because *T. auratus* was leaf eater (Kool 1993) and *M. fascicularis* was also leaf eater when its main food getting scarce. During data collection, we tied plastic rope on the branch or pole every 100 m as sign of data collection point for habitat attribute.

Habitat attributes

Habitat characteristics that were considered to affect the primate population density including the number of tree species (Ross and Srivastava 1994; Kankam and Sicote 2013), the number of food trees species (~~Cristobal-Azkarate and Arroyo-Rodriguez 2007; Mammides *et al.* 2008;~~ Pozo-Montuy *et al.* 2011), tree density (Ross and Srivastava 1994; Wieczkowski 2004), and food tree density (Anderson *et al.* 2007). Habitat data were collected after population data were gathered line transect (Soerianegara and Indrawan 2005). Sample plots were established every 100 m along transect of grizzled leaf monkey population. Size of each plot was 20 m x 20 m (Kusmana and Istomo 1995). We recorded data of species name and diameter at breast height for each tree with diameter ≥ 10 cm (Onderdonk and Chapman 2000). Trees with diameter ≥ 10 cm were considered strong and big enough for primates to be used in feeding activity (Worman and Chapman 2006). This study did not collect data of undergrowth and trees with diameters less than 10 cm due to arboreal characteristic of grizzled leaf monkey (Ruhiyat 1983; Gunawan *et al.* 2008). Unkown tree species found in sample plots was identified at Bogoriense Herbarium of Indonesian Institute of Sciences. Food trees species of grizzled leaf monkey were identified by three approachments namely study of previous research (for example, Ruhiyat 1983, Melisch and Dirgayusa 1996, Farida and Harun 2000), interview with local community who often found grizzled leaf monkey groups, and direct observation.

Commented [VN11]: I know they are less relevant for your study but it would be good if you could indicate if the Javan slow loris and the Javan gibbon were or were not present in the area.

Commented [VN12]: Again see comment 8

Commented [VN13]: I would not mind seeing a list of these tree species

Commented [VN14]: Two of these studies are in montane forest and Melish and Dirgayusa only observed six species that the leaf monkeys fed on.

Spatial attributes

This study also includes spatial attributes which predicted to influence primate population density. The variables were research site distance to nearest natural forest (Estrada and Coates-Estrada 1996; Pozo-Montuy *et al*. 2011), research site distance to the nearest settlement and road (Arroyo-Rodriguez *et al*. 2008). The distance of each location to the larger natural forest edge was obtained by measuring average distance from coordinates of the initial point of line transect and projecting the distance using Google Earth Map. Similar method was used to obtain the distance from each location to the earest road and settlement.

Habitat disturbance attribute

Habitat disturbance attribute collected in the research was tree stump density as an indicator of disturbance level and habitat destruction through logging (Wood and Gillman 1998). Logging was expected to negatively affect the density of primates (Chapman *et al*. 2007). Data were collected in parallel with vegetation data in the sample plot. Stump were recorded limited to undecayed one.

Data Analysis

Estimation of population density in this study was calculated using mean of all line transect. We attempt to obtain a general overview and estimate the population density of each site to identify the controlling factors of the population density. The estimation of entire research site begun with group density estimation (Martins 2005) using the following formula:

$$D = \text{detected group number} / 2(\text{ESW}) \, . \, L$$

where D = grizzled leaf monkey group density (group/ km^2), ESW = effective wide (m), and L = total line transect (km). ESW value obtained using Distance software 5.0. The population density was obtained by multiplying the density of the group with an average size of groups from entire research sites (Martins 2005; Fashing *et al*. 2012). Estimations of population density in each transect was also using the same formula using the number of groups in each transect, transect length, and the average size of groups of each location. We rarely found more than one group in one transect, thus we used one ESW value for transects. The same technique was used to estimate ebony langur and long~~-~~-tailed ~~monkey~~ macaque population density which were going to be used as free variable on each location.

Habitat characteristics were analyzed by descriptive (mean and standard deviation). Ebony l~~L~~angur and ~~long~~ long-tailed ~~monkey~~ macaque population, after the density was known, was also followed by a descriptive analysis. Selection of variables identified as a good predictor for grizzled leaf monkey population density was done through three stages. The first stage was to analyze the data distribution using Kolmogorov-Smirnov test. Data is normally distributed if $p > 0.05$. We then run a Pearson correlation test among all independent variables at $p \leq 0.05$ (Anzures-Dadda and Manson 2007; Arroyo-Rodriguez *et al*. 2008). In multiple regression, the number of tree species were excluded from the analysis due to significant correlation number of food tree species ($r = 0.90$; $p < 0.001$). Total tree density was excluded due to its correlation to food tree density ($r = 0.58$; $p = 0.009$) and tree stump density ($r = 0.46$; $p = 0.050$). The research site distance to nearest settlement also excluded for the strong correlation with distance to the nearest road and forest area ($r = 0.94$; $p < 0.001$, $r = 0.46$; $p = 0.048$) respectively. Furthermore, to identify habitat components significantly influence population density, multiple linear regression through stepwise method was used (Mbora and Meikle 2004) using SPSS 21 software. The significance level used was (α) ≤ 0.05. Contribution rate of combined variables to population density can be seen through R^2 value.

Results

Population density

We conducted this study in 19~~23~~ forest divisions with total line transect of ~~122.23~~100.3 km. The total population of grizzled leaf monkey from the line transects and its nearby area were 486 originated from 65 groups.~~ Thus, we estimate there were 7.48 ± 5.35 leaf monkeys per group.~~ However, population density in this study was calculated based on 41 groups found in the line transects so that is 0.41 groups km^{-1} of transect. We used Distance ver. 5.0 to estimate group density of ~~4.63~~5.66 groups km^{-2} (min = 4.68 groups km^{-2}; max = 6.85 groups km^{-2}) ~~±2.80 km^{-2}~~. This study estimates the population density of 44.71 individuals km^{-2} (min = 36.97 individuals km^{-2}; max = 54.12 individuals km^{-2}) ~~34.63 ± 19.07 individuals km^{-2}~~ calculated by multiplying mean of group size and group density. The mean of group size used is 7.9 individuals (Nijman 2017). ~~No monkey was observed on 4 forest plots at our research site. Therefore, we excluded this plots and analysis was conducted based on 19 forests division data. During this study we re-~~

Commented [VN15]: No need to add this here but Nijman found that in lowland forest below 1000 m asl the mean group size was 7.9±3.0 individuals, so very similar.

Commented [VN16]: So that is 0.33 groups / km of transect

Commented [VN17]: Am I correct to conclude that the ESW is 36 m?

~~interviewed respondents who is familiar with the plot history to obtain further data on existence of the monkey in these 4 plots. Respondents were confident that the plots were habitat of this monkey. Nevertheless, we decided to exclude those plots.~~ Effective plot wide to estimate the population density was 36.~~1~~16 m. ~~with a total line transect of 100.3 km. Mean of populations density was 45±42.03 (mean±SD) and it ranged from 7.68-184.36 individuals km-2.~~

Commented [VN18]: This latter bit is a bit unclear to me

Habitat characteristic

Data of habitat characteristic is developed from 19 forest divisions divided into 1003 plots. Data of all measured variables were normally distributed. Descriptive statistic and Kolmogorov-Smirnov test of the 7 variables used to estimate population density are presented in Table 1.

Table 1 Descriptive statistic and Kolmogorov-Smirnov test of habitat and other factors influencing grizzled leaf monkey in production forest of Kuningan District (all based on 19 forest divisions)

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Variable	Mean	SD	Kolmogorov-Smirnov test	
			Z	P
Ebony l~~L~~angur population density (individuals km^{-2})	144.16	103.51	0.517	0.952
Long tailed macaque ~~monkey~~ density (individuals km^{-2})	40.47	74.67	1.281	0.075
Number of food tree species (species ha^{-1})	22.21	4.25	0.717	0.683
Food tree density (individuals ha^{-1})	158.24	43.88	0.798	0.548
Stump density (individuals ha^{-1})	2.10	3.19	1.126	0.159
Research site distance to the nearest road (km)	0.59	0.38	0.699	0.713
Research site distance to the nearest forest area (km)	12.57	6.42	0.549	0.924

Factors controlling population density

This research found two out of seven variables were significantly related to grizzled leaf monkey density in this production forest which are number of food tree species and stump density. The effect of each variable were contradictory (Table 2). Number of food tree species displayed significant positive relationship with the monkey population while increasing stump density were significantly decrease the monkey population. Increasing of stump number indicates an increasing of forest disturbance. Both variables are responsible to explain 40% variability of the monkey population density ($R^2 = 0.40$; $F = 5.33$; $p = 0.017$). However there were no significant relationship ($p > 0.05$) between the monkey population density and other measured variables including food tree density, langur population density, distance of research site to the nearest road and forest area. Thus, we suggest that number of food tree species and stump density are good predictors to estimate the monkey population density.

Table 2 Variables significantly related to *Presbytis comata* population density

Model	Constant (SE)	T	P
Constant	-60.92 (43.28)	-1.408	0.178
Number of food tree species (species ha^{-1})	5.32 (1.94)	2.739	0.015
Stump density (ind ha^{-1})	-5.79 (2.59)	-2.237	0.040

Discussion

The study of evaluating grizzled leaf monkey population density in a production forest is limited. Previous studies have been conducted mainly in conservation forest. Thus, we suggest that it will contribute to a better estimation of grizzled leaf monkey population in Indonesia. We recorded 486 animals in this study and suggest that it will increase our current estimate of the monkey total population. A more recent estimate for the number of grizzled leaf monkey population on Java, based on 11 areas where the species was studied, is 1,760 – 2,360 groups; with a group size of just over seven individuals, that translates to between 13,000 and 17,000 individuals (Nijman 2017). ~~by 21.3 % considering latest data estimate of 2285 individuals (Supriatna *et al*. 1994).~~ Our results also provide information on controlling factors effecting the monkey population. It confirms that the monkey population was influenced by food

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availability and habitat disturbance due to human activities. Forests areas with high variability of food tree species have higher population density as it can provide sufficient food to support the monkey population. Population density was decreasing as the response to increase logging or timber harvesting.

Comparison of this study to other similar research has been difficult due to no literature available on population estimated from production forest. Thus, we compared this study with previous studies conducted in conservation forests. Our study found similar population density of grizzled leaf monkey in Situ Patenggang Nature Reserve (Ruhiyat 1983). However, our results were ~~ninefold~~ eleven and ~~triple~~ six times ~~than~~ that in Ujung Kulon National Park and Gunung Ciremai National Park respectively (Heriyanto and Iskandar 2004; Kartono *et al*. 2009). In the Dieng Mountains, the density of the grizzled groups range from 1.2 to 4.4 group km^{-2} (Nijman and Nekaris 2013). By combining the results of previous studies, group density ranges from 0.4 to 0.6 groups km^{-2} in lowland forest and 0.5-2.4 groups km^{-2} in hilly forest (Nijman 2017). This also shows that the results of this study are higher than other studies. Sufficient information were not available to explain the difference estimate and variability. We suggest that the effect of different methods applied and quality of the habitats affected this findings. Nevertheless, it is important to recognize that this study provided the first evidence on the significant contribution of production forest to support the monkey population. Grizzled leaf monkey has been listed by IUCN as E~~e~~ndangered species for almost 20~~8~~ years since 1988 (Nijman and Richardson 2008). Identification of new potential habitats and its population, for example by this study site, will be imperative to the monkey conservation.

Lowland forests have been identified as grizzled leaf monkey main habitat (Hoogerwe~~o~~rf 1970), most likely due to the variability of food tree species available. Hence, high variability of tree species in natural forest resulted in high variability of food sources and habitat quality (Li 2004; Arroyo-Rodriguez and Mandujano 2006). Similarly, positive correlation between number species of food tree and the monkey population in our study showed the important of food sources variabilities to support the survival of the monkey. This result is in line with previous research in Gunung Merbabu National Park showing that the grizzled was mostly distributed in forests that have diverse plant species (Handayani and Latifiana 2019) because the higher the plant diversity the higher the chance of feed diversity. In Kusumanegara *et al.* (2017) study in the National Park, the grizzled was often found in areas close to the forest edge. However, that study did not compare the diversity of food trees between the edge and the middle of the forest so that it was not yet able to answer whether the high encounter in the edge was related to the diversity of food

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Commented [VN22]: The most recent update was 2008 (Nijman and Richardson) and we are hoping that an update will come out soon. It still will be listed as Endangered trees or not (Kusumanegara *et al.* 2017). In the study of Kartono *et al*. (2009) in Gunung Ciremai National Park, population density was affected by the density of 9 species of trees, namely: *Podocarpus neriifolius*, *Saprosma arborea*, *Glochidion arborescens*, *Palaquium impressinervium*, *Ficus* sp., *Psychotria* sp., *Litsea sanguinolenta*, *Lithocarpus ewyckii*, dan *Lithocarpus sundaicus*. Previous studies on other primates population density were also in agreement with our findings including ~~*Procolobus gordonorum* population in Udzungwa Mountain National Park (Rovero and Struhsaker 2007), *Colobus guereza* and *Cercopithecus mitis* population in Kakamega forest, Kenya (Mammides *et al*. 2008),~~ *P*resbytis~~.~~ *kirkii* in Zanzibar (Siex and Struhsaker 1999)~~,~~ and *P. rubicunda* di Sepilok nature reserve, Malaysia (Davies *et al*. 1988). Cristobal-Azkarate dan Arroyo-Rodriguez (2007) reported that howler monkey (*Alouatta palliata*) population depends on number species of food tree. In Cabeza del Toro and the Santuario Nacional Cordillera de Colan, Peru, ocuppancy probabilty of Peruvian night monkey *Aotus miconax* has a positif correlation with diversity of the vegetation (Campbell *et al*. 2019). ~~–~~Based on the results of our research and other previous studies, this shows that enrichment of tree species needs to be done in production forests.

Commented [VN23]: I would make more comparisons with other studies that have been conducted on P. comata rather than on other species on different continents.

Population density is likely determined by the variability of food tree species to support primate nutrition (Cristobal-Azkarate *et al*. 2005) including carbohidrate, protein, fat, vitamin and mineral (Chapman *et al*. 2012). Main nutrition of primate from sub family colobine is obtained from leaf (Ruhiyat 1983; Kirkpatrick 1999; Wasserman and Chapman 2003). However, each tree species has different leaf nutrition and energy content (Farida and Harun 2000; Nelson *et al*. 2000; Wasserman and Chapman 2003; Hockings *et al*. 2009). For example, *Albizia falcataria* has higher protein (26.34%) and energy (5.17 kkal gram^{-1}) compare to *Ficus padana* with protein content of 14.64% and energy of 4.69 kkal gram^{-1}. In addition, *A. falcataria*has lower fat (0.96%) than that of *F. padana* (2.93%) (Farida and Harun 2000). Grizzled leaf monkey also consumes fruits (Ruhiyat 1983) which usually have different fruiting season among tree species (K~~e~~oenig *et al*. 1997; Hockings *et al*. 2009) and variability of nutrient content (Milton 2003; Wasserman and Chapman 2003). Therefore, primate consumes only specific food unlikely to fulfill its nutrient need. Primate requires sufficient and balance nutrition to support reproduction, grow, development and survival (K~~e~~oenig *et al*. 1997; Felton *et al*. 2009; Chapman *et al*. 2012). It is important for primates to eat different food tree species (Cristobal-Azkarate *et al*. 2005; Chaves *et al*. 2011). We suggest that the above conditions can explain why the monkey were found at forest with high variability of food tree species.

In addition, our study also identify the significant influence of stump density on the monkey population. Forest disturbance has been detected as one of factors controlling the monkey population. The remaining stump left in sites after timber harvesting can determine site level disturbance. The monkey populations were lower in sites with high stumps density as the negative effect of logging. This result is in agreement with previous studies in other locations including *Galago demidovii*, *G. inustus*, and *Perodictus potto* in Kibale forest (Weisenseel *et al*. 1993), chimpanzee in western Equatorial of Africa (Morgan and Sanz 2007), *Procolobus pennantii* and *Colobus guereza* in western Uganda (Chapman *et al*. 2007). Logging has been responsible to declining of *Lophocebus albigena* group density of Kibale Natinal Park in Uganda (Chapman *et al*. 2000). Negative effect of logging also observed on Congo's gorillas population due to available access of poachers through the logging tract (Haurez *et al*. 2013). Our research site is located in a production forest where logging activity is a must. It is important to further examine effective logging intensity to obtain economic benefit and at the same time ensure sustainability of the monkey population.

Similar to other primates, grizzled leaf monkey is also categorized as shy animal (Ruhiyat 1983) that avoid interaction with human (Nijman and Nekaris 2013; Tobing 1999). During logging activities, workers and the sound of logging machine (chainsaw) will create a noisy environment that trigger the monkey to move to other locations. As a result, the monkey population density will be lower than that in less human disturbance areas. This is consistent with research conducted by Tobing (1999) in Gunung Halimun National Park showing that the populations density in undisturbed forests tend to be higher than that in disturbed ones. Li (2004) reported decreasing population of snub-nosed monkey (*Rhinopithecus roxellana*) in Shennongjia nature reserve in China due to human activity.

Our hypothesis was food tree density will positively correlate to the monkey population in accordance with the studies on *Procolobus rufomitratus, Pan troglodytes, Alouatta pigra* (Balcomb *et al*. 2000; Mbora and Meikle 2004; Pozo-Montuy *et al*. 2011). In addition, our preliminary hypothesis was *T. auratus* and *M. fascicularis* density will negatively influence grizzled leaf monkey due to consuming similar diet (Kool 1992; Kool 1993; Yeager 1996). However, results of this study were not in agreement with hypothesis. No response of food tree density on the monkey population implies that food availability was yet to be the limiting factor (Yeager and Kirkpatrick 1998). We suspect that the monkey has flexibility on food sources in accordance with general characteristic of *Colobus angolensis palliatus* species (Anderson *et al*. 2007) under the subfamily colobinae (Rowe 1996).

Asian colobine can consume young and old leaf as a source of diet (Yeager and Kirkpatrick 1998). Leaf is considered as relatively stable and abundance food sources (Chapman 1990). Therefore, food need of Asian colobine including grizzled leaf monkey is still bellow environment carrying capacity (Yeager and Kirkpatrick 1998). Thus no competition observed between the monkey and *T. auratus* dan *M. fascicularis* to fulfill food need. We propose the above reason behind no relationship between the monkey and other primates.

We measured also the relationship of the monkey population and plot distance to the nearest road. We assumed that road construction also represent the nearest community settlement. Arroyo-Rodriguez *et al*. (2008) reported that road displayed significant positive correlation with *Alouatta palliata mexicana* population. However, our results are not agreement with this study. We suggest that the different response was due to higher intensity of human activity in this study than that in our research site. We also suggest that the different species studied contribute also to this difference. No response of grizzled leaf monkey population to nearest road indicated that this variable is yet to be the monkey threat. Similar to study on *C. angolensis palliatus* population in Kenya beach forest (Anderson *et al*. 2007). We presume that vehicle and human activities in our research site is still under the monkey tolerance and they have been adapting to the condition. Inconsistent monkey population has also contributed to this finding as proposed by Anderson *et al*. (2007).

Estrada and Coates-Estrada (1996) reported primate distance to nearest forest ecosystem will influence spot where the population can be found. To measure this effect we tested the influence of our research site distance to nearest forest area of Gunung Subang forest (GS). We found the opposite result compare to previous studies of Cristobal-Azkarate *et al*. (2005) and Arroyo-Rodriguez *et al*. (2008) on *A. palliata mexicana* population in Los Tuxtlas Mexico. Our results were also in contrary to Pozo-Montuy *et al*. (2011) study that found the farther distance from nearest forest the lower *A. pigra* population. We propose that the different was due different species characteristics and site specific condition, however, the actual reason is still unidentified. We suspected that the length wise position of our research site toward the GS forest with agricultural and settlement in both side created no corridor for the monkey movement. We understand that corridor is an important aspect to allow animal migration including primates (Anzures-Dadda and Manson 2007). There was also a pine forest and road construction located between our research site and GS forest. However, we urge that further research is needed to identify the controlling factors of the monkey population in relation to nearest forest distance.

This research was conducted in one forest landscape in one district. Further campaigns in other districts of the monkey habitat need to be examined. This is to establish a robust estimate of population density and the controlling factors since our results only explained less than 50% of population variability. Further research should consider a larger study site, straight observation line rather using available track in the site, expanding environmental variables including food source from lianas (Ruhiyat 1983) and protein to fiber of food tree species.

In Indonesia, the government also owns a plantation company called PT Perhutani. Conservation approach can be tested at those plantations by mixing main species with food tree species including pulai (*Alstonia scholaris*), saninten (*Castanopsis argentea*), kondang (*Ficus glomerata*), walen (*Ficus ribes*), beunying (*Ficus* sp.), kareumbi (*Omalanthus populneus*), pasang (*Quercus* sp.), and peutag (*Syzygium lineatum*) (Ruhiyat 1983). In mixed farms, in addition to planting food tree species, increasing the proportion and number of multipurpose tree using non-timber forest product species can be planted including cloves, coconut, mango, mangosteen, melinjo, rambutan, nutmeg, and guava can seen as. Enrichment in forests with low feed tree species can expand habitats suitable for the grizzled because the species can only survive in forest > 50 km^2 (Nijman 2013). Nonetheless, population management of grizzled monkey population in production forests including mixed farms require more in-depth study that involve relevant stakeholders to sustain both conservation and economic benefits.

Variability of food tree species and level of forest disturbance due to logging activity were the controlling factors of grizzled leaf monkey population. Conservation efforts of the monkey in the future should consider these environmental variables. Balance proportion of commercial tree species and at the same time planting sufficient food tree species will contribute to sustainability of this effort while at the same time ensure the economic benefit of company. We suggest that this approach can be replicated in other conservation activities in particular for production forest area. However, further research is needed involving bigger area and more environmental variables.

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Appendix

List of Food Tree Species for *Presbytis comata* from 19 sites in Kuningan District, West Java, Indonesia

No	**Scientific Name**	**Family**
1	*Aglaia argentea* Blume	Meliaceae
2	*Aglaia odorata* Lour.	Meliaceae
3	*Aglaia* sp.1	Meliaceae
4	*Alangium rotundifolium* (Hassk.) Bloemb.	Cornaceae
5	*Albizia falcataria* (L.) Fosberg	Leguminosae
6	*Albizia procera* (Roxb.) Benth	Leguminosae
7	*Aleurites moluccana* (L.) Willd	Euphorbiaceae
8	*Alseodaphne umbelliflora* Hook.f.	Lauraceae
9	*Alstonia scholaris* R. Br.	Apocynaceae
10	*Antidesma bunius* (L.) Spreng	Phyllanthaceae
11	*Antidesma montanum* Blume	Phyllanthaceae
12	*Archidendron pauciflorum* (Benth.) Nielsen	Leguminosae
13	*Arthrophyllum diversifolium* Blume	Araliaceae
14	*Artocarpus elastica* Reinw	Moraceae
15	*Artocarpus heterophyllus* Lam	Moraceae
16	*Baccaurea javanica* Muell. Arg.	Phyllanthaceae
17	*Bischofia javanica* Blume	Phyllanthaceae
18	*Blumeodendron tokbrai* (Blume) Kurz	Euphorbiaceae
19	*Bridelia monoica* Merr.	Phyllanthaceae

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No	Scientific Name	Family
20	*Calliandra callothyrsus*	Leguminosae
21	*Cananga odorata* (Lamk.) Hook.	Annonaceae
22	*Canthium glabrum* Blume	Rubiaceae
23	*Cassia siamea* Lamk	Leguminosae
24	*Castanopsis argentea* A. DC.	Fagaceae
25	*Castanopsis tungurrut* A. DC.	Fagaceae
26	*Ceiba pentandra* L. Gaertn	Bombacaceae
27	*Cinnamomum burmannii* (Nees & T.Nees) Blume	Lauraceae
28	*Cinnamomum iners* Reinw. ex Blume	Lauraceae
29	*Coffea* sp.	Rubiaceae
30	*Croton argyratus* Blume	Euphorbiaceae
31	*Cryptocarya ferrea* Blume	Lauraceae
32	*Dalbergia latifolia* Roxb	Leguminosae
33	*Dillenia indica* L.	Dilleniaceae
34	*Diospyros macrophylla* Blume	Ebenaceae
35	*Dracontomelum dao* Merr. & Rolfe	Anacardiaceae
36	*Dysoxylum macrocarpum* Blume	Meliaceae
37	*Elaeocarpus glaber* Blume	Elaeocarpaceae
38	*Erythrina lithosperma* Miq	Leguminosae
39	*Eurya acuminata* DC.	Pentaphyllaceae
40	*Ficus ampelas* Burm.f.	Moraceae
41	*Ficus fistulosa* Reinw. ex Blume	Moraceae
42	*Ficus magnoliaefolia* Blume	Moraceae
43	*Ficus padana* Burm.f.	Moraceae
44	*Ficus ribes* Reinw.	Moraceae
45	*Ficus septica* Burm. F.	Moraceae
46	*Ficus sumatrana* Miq.	Moraceae
47	*Ficus variegata* Blume	Moraceae
48	*Flacourtia rukam* Zoll.& Mor.	Salixaceae
49	*Garcinia parvifolia* (Miq.) Miq.	Clusiaceae
50	*Geunsia pentandra* Merrill	Lamiaceae
51	*Gironniera cuspidata* (Blume) Kurz	Canabaceae
52	*Gliricidia sepium* H.B.K.	Leguminosae
53	*Glochidion arborescens* Blume	Phyllanthaceae
54	*Glochidion philippicum* (Cav.) C.B. Rob.	Phyllanthaceae
55	*Gnetum gnemon* L.	Gnetaceae

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No	Scientific Name	Family
56	*Grewia laevigata* Vahl	Malvaceae
57	*Hibiscus macrophyllus* Roxb. ex Hornem	Malvaceae
58	*Homalanthus populneus* (Giesel.) Pax	Euphorbiaceae
59	*Knema cinerea* Warb.	Myristicaceae
60	*Lansium domesticum* Corr	Meliaceae
61	*Leucaena leucocephala* (Lam.) de Wit	Leguminosae
62	*Macaranga tanarius* (L.) M.A.	Euphorbiaceae
63	*Macaranga triloba* (Reinw.ex Blume) Muell. Arg.	Euphorbiaceae
64	*Macropanax dispermus* (Blume) O.K.	Araliaceae
65	*Maesopsis eminii*	Rhamnaceae.
66	*Mallotus* sp.1	Euphorbiaceae
67	*Mangifera foetida* Lour	Anacardiaceae
68	*Mangifera longipes* Griff.	Anacardiaceae
69	*Melia azedarach* L	Meliaceae
70	*Melicope lunu-akenda* (Gaertn.) T.G. Hartley	Rutaceae
71	*Meliosma ferruginea* Blume	Sabiaceae
72	*Melochia umbellata* (Houtt.) Stapf.	Malvaceae
73	*Michelia velutina*	Magnoliaceae
74	*Nauclea orientalis* L.	Rubiaceae
75	*Neonauclea obtusa* (Blume) Merr.	Rubiaceae
76	*Nephelium lappaceum* L	Sapindaceae
77	*Oreocnide rubescens* (Blume) Miq.	Urticaceae
78	*Ostodes paniculata* Blume	Euphorbiaceae
79	*Pangium edule* Reinw	Achariaceae
80	*Paraserianthes falcataria* (L.) Nielsen	Leguminosae
81	*Paratocarpus venenosa* (Z.& M.) Becc.	Moraceae
82	*Parkia javanica* (Lam.) Merr.	Leguminosae
83	*Parkia speciosa* Hassk	Leguminosae
84	*Persea americana* P. Mill.	Lauraceae
85	*Persea rimosa* Zoll. ex Meisn.	Lauraceae
86	*Piper aduncum* L.	Piperaceae
87	*Pittosporum ramiflorum* Zoll. ex Miq.	Pittosporaceae
88	*Planchonia valida* Blume	Lecythidaceae
89	*Platea excelsa* Blume	Icacinaceae
90	*Radermachera gigantea* (Blume) Miq.	Bignoniaceae
91	*Samanea saman* (Jacq.) Merr	Leguminosae

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92	*Saurauia bracteosa* DC.	Actinidiaceae
93	*Saurauia reinwardtiana* Blume	Actinidiaceae
94	*Schima wallichii* (DC.) Korth.	Theaceae
95	*Schleichera oleosa* Merrill	Sapindaceae
96	*Sterculia oblongata* R. Br.	Malvaceae
97	*Symplocos fasciculata* Zoll.	Symplocaceae
98	*Syzygium lineatum* (DC.) Merr. & Perry	Myrtaceae
99	*Syzygium polyanthum* Wigh Walp	Myrtaceae
100	*Tabernaemontana sphaerocarpa* Blume	Apocynaceae
101	*Terminalia belirica* (Gaertn.) Roxb.	Combretaceae
102	*Toona sureni* (Blume) Merr.	Meliaceae
103	*Turpinia sphaerocarpa* Hassk.	Staphyleaceae
104	*Vernonia arborea* Buch. - Ham.	Compositae
105	*Vitex pinnata* L.	Lamiaceae
106	*Xanthophyllum excelsum* (Blume) Miq.	Polygalaceae

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Lampiran 5. Respon Atas Komentar Reviewer

List of Comments and Response to Reviewer

Title Manuscript: Controlling Factors of Grizzled Leaf Monkey (*Presbytis comata*) Population Density in a Production Forest in Kuningan District, West Java, Indonesia

General response

We thank the editor of the Primate Conservation journal who has responded to our manuscript and to reviewers who have provided suggestions and corrections to this manuscript. There are many positive things that I get from these suggestions and comments. Furthermore, we also hope that this manuscript is suitable for publication in the journal Primate Conservation.

Regarding general comments from reviewers, we convey the following responses:

1. We have included Prof. Nijman's research as important information in our manuscript
2. Several other studies related to P. comata have been included in our manuscript
3. We have included a list of food plants in the appendix
4. We did not find Javan gibbon during the study. Slow loris is only found once near the rice fields, outside the research plot. Therefore, these two species are not used as independent variables in our study.
5. In the discussion, we have included other studies on surili.
6. We have included a map of the research locations.

List of Comments and Response

No	Comment	Response
VN1	This is a paper about food selection in a different species of langur, Trachypithecus auratus, so I suggest to use a different reference. I recently published a wide-ranging overview of the ecology of P. comata – Nijman 2017 – see references	We have changed it. Species distribution has referred to the publication of Nijman (2017).
VN2	I think that if you read some of the more recent papers, you will find that the MacKinnon	We have used the 2018 data to present the remaining forest area in Java

No	Comment	Response
	etimate is a bit outdated. I would use some more recent references.	
VN3	Nijman and van Balen (1998) studied them in lowlands; also see the overview paper by Nijman (2017) as it has all the recent large populations listed by altitude.	We have referred to and included the two research results of Nijman and van Balen (1998) and Nijman (2017)
VN4	But Sujatnika studied them in the mountains – and, agreed in Jasinga which is in the lowlands, but there were only very few grizzled leaf monkeys there – one group if I recall correctly.	Reference to Sujatnika's research results has been removed or not used
VN5	Again see Nijman 2017 as there is more information in there.	We have included research results from Nijman (2017)
VN6	Whilte I think it is good to refer to a wide range of papers, I think here it would suffice if you were to pick just two or three.	We have selected three references which are considered more relevant
VN7	Unclear what you mean – there has been quite a bit more research done on them; perhaps check Nijman 2017 again.	The purpose of the sentence is that research on the factors that influence the density of surili populations is still limited. That sentence has been corrected. Research from Nijman (2017) has also been included in this explanation.
VN8	See comment 6	We have selected three references that are considered most relevant
VN9	This is a wide range – how come?	We obtained it from the official Kuningan district government document. The range is like that.
VN10	This is interesting as this suggests the transects (or paths) were not placed in a random or somehow organised manner, but focussed on areas where local people indicated the presence of the leaf monkeys. While I have no real issue with this, this makes it difficult to extrapolate to total population size in the area.	Kuningan Regency consists of 376 villages. Based on the results of information gathering from the community, surili is spread in villages with connected forest ecosystems. Gathering information to the public was the first step of research. Data collection was carried out in locations that are sure to have a surili group. Extrapolation of total population can only be done to forests that have surili populations, although in this study we did not extrapolate to total population. The sentence has been corrected.
VN11	I know they are less relevant for your study but it would be good if you could indicate if the Javan slow loris and the Javan gibbon were or	The sentence has been corrected and contains information about the presence or absence of slow loris and Javan gibbon.

No	Comment	Response
	were not present in the area.	
VN12	Again see comment 8	We have selected the most recent reference
VN13	I would not mind seeing a list of these tree species	The feed trees species are shown in the appendix
VN14	Two of these studies are in montane forest and Melish and Dirgayusa only observed six species that the leaf monkeys fed on.	Publications about surili feed are still limited so we use these three publications, in addition to community interviews and direct observations.
VN15	No need to add this here but Nijman found that in lowland forest below 1000 m asl the mean group size was 7.9±3.0 individuals, so very similar.	The sentence has been removed. The group size used in estimating populations is 7.9 individuals (Nijman 2017).
VN16	So that is 0.33 groups / km of transect.	We have corrected it so that the relative density is 0.41 groups km^{-1}
VN17	Am I correct to conclude that the ESW is 36 m?	Yes, ESW is 36
VN18	This latter bit is a bit unclear to me.	The paragraph has been corrected. The total transect line used is 100,226 km.
VN19	So you can remove the column with seven entries of '19'.	We used 7 variables for each of the 19 study sites
VN20	A more recent estimate for the number of grizzled leaf monkey population on Java (based on 'just' 11 areas where the species was studied) is 1,760 – 2,360 groups; with a group size of just over seven individuals, that translates to between 13,000 and 17,000 individuals. Suggest to rewrite this.	We have rewritten the estimation of the population. Thank you for the advice.
VN21	Again check Nijman 2017 and the references therein and you may want to rewrite this a little bit.	We have rechecked it and included some information in our manuscript.
VN22	The most recent update was 2008 (Nijman and Richardson) and we are hoping that an update will come out soon. It still will be listed as Endangered.	We have used references from Nijman and Richardson (2008) to update the IUCN status of these species.

No	Comment	Response
VN23	I would make more comparisons with other studies that have been conducted on P. comata rather than on other species on different continents.	We have compared it with studies of surili populations in other place.

Lampiran 6. Respon terhadap komentar dari editor

List of Comments and Response

Title Manuscript: Controlling Factors of Grizzled Leaf Monkey (*Presbytis comata*) Population Density in a Production Forest in Kuningan District, West Java, Indonesia

General response

1. We thank you very much for your kindness for being willing to improve, give advice, and provide opportunities to revisit this manuscript.
2. We have improved the manuscript according to comments and suggestions, including increasing map resolution and including photographs of *Prebytis comata* in the manuscript.
3. There was a slight error in writing my name on "Left page" in manuscript, written Supartano et al; this should Supartono et al., but I have fixed it.

List of Comments and Response

No	Comment	Response
AR1	Is this something? If not, delete.	We have deleted the sentence.
AR2	The image is blurry, evidently low resolution. Can you please provide a higher resolution image of at least 360 dpi at this size?	We have replaced the map resolution with 400 dpi.
AR3	How many line transects – 19? Were they repeated? How many surveys on each trail? What was the transect width for each species? It would be useful to put all this in a table perhaps.	The number and total number of lines transects in each location have been added in Table 1. We did not repeated each transect because the topography is mostly steep. The survey was conducted one time. The effective width of the transects used to estimate the density of each species has been added to the manuscript and was obtained or known after all field data has been entered at Distance 5.0.
AR4	Are you referring to the cut-off distance for sightings either side of the path? That is, was the transect width 2 x 36.16 m? This is not a result - it should be in the Methods	Yes, the width of the transect refers to the cut-off, which is 2 x 36.16 m, which is obtained after all data from all transects are entered at Distance 5.0. We have removed the value in the results section and presented it in the methods section; along with responding to comment 3.

No	Comment	Response
	section.	
AR5	I am afraid I was not able to understand this paragraph or make any sense of it. I suggest that you delete it. You have stated in the results that there was no effect of the “distance of the transects to the nearest road and forest” That should be enough.	We have deleted the paragraph. Thank you for the advice.

Lampiran 7. Naskah yang sudah dikoreksi

Controlling Factors of Grizzled Leaf Monkey (Presbytis comata) Population Density in a Production Forest in Kuningan District, West Java, Indonesia

Toto Supartono[1], Lilik Budi Prasetyo[2], Agus Hikmat[2], Agus Priyono Kartono[2]

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Abstract: Land use change and deforestation continues in Indonesia at an alarming rate, resulting in widespread loss of habitat for wildlife. In this study, we propose that a production forest can serve as a refuge for otherwise afflicted animal populations. Information on population densities and an understanding of the influencing factors are important to evaluate the efficacy of protected areas. Very little is known in this regard, however, for the species in question here, the Endangered grizzled leaf monkey, *Presbytis comata*. Here we report on a study to estimate the population density of this langur (and other primates) in a production forest and to identify the controlling factors. We conducted population surveys in 19 forest patches and recorded the numbers and density of tree species that figure in the diet of the langur. We also counted tree stumps, an indication of the intensity of logging. We measured the distance of each of the 19 forest patches to the nearest road, the nearest settlement, and to other forest patches. Descriptive statistics and multiple linear regression were used in data analysis. We recorded population densities of 36.97 to 54.12 individuals/km² (mean = 44.71 ind./km²). Densities were positively correlated with the number of food tree species, but negatively related to the density of tree stumps, an indicator of habitat disturbance due to timber extraction. Our results indicate that the diversity of food tree species and logging activities should be taken into consideration in formulating conservation strategies of grizzled leaf monkey population in production forests.

Keywords: grizzled leaf monkey, *Presbytis comata*, population density, food trees, conservation, production forest.

Introduction

Tropical forests continue to decline, and their loss, fragmentation and degradation is one of the major issues in biodiversity conservation. Production forests, generally in the form of mixed plantations, can, however, be important in the conservation of wildlife communities (Brockerhoff *et al*. 2008; Lindenmayer *et al*. 2009; Rayadin and Saitoh 2009; Salek *et al*. 2010; Van Halder *et al.* 2011; Fashing *et al.* 2012). Appropriately managed protected areas of this sort can increase options for wildlife and landscape conservation, reducing as such the dependency on strictly protected areas. In Indonesia, many production forests have become refuges for dispersing and displaced wildlife populations (Marsden *et al*. 2001; Luckett *et al.* 2004; Pawson *et al.* 2008; Lindenmayer *et al*. 2009; Van Halder *et al.* 2011), including those of nationally protected and threatened species (for example, *Hylobates agilis*, *H. lar*, and *M. nemestrina*: Nasi *et al*. 2008; orangutan: Rayadin and Spehar 2015). Some species are quite able to persist in these forests once they provide food, sleeping sites and sufficient area, counting on corridors to allow for genetic exchange (Ganzhorn 1987; Rayadin and Saitoh 2009; Yamada and Muroyama 2010; Henzi *et al*. 2011; Campbell-Smith *et al.* 2012).

The Javan grizzled langur, *Presbytis comata*, has a restricted range in West Java, east to Mt. Lawu on the border with East Java (Nijman 2013, 2017). It is Endangered (Nijman and Richardson 2008), and nationally protected (Regulation No. P.20/Menlhk/Setjen/Kum. 1/6/2018) and has been identified as a conservation priority by the Indonesian government (Regulation No.P.57/Menhut-II/2008). The principal habitat for this species was forest in the lowlands and hills (Hoogerworf 1970; Nijman 1997), but its range is today largely restricted to montane forest (Nijman 1997). Due to a long history of land conversion (Whitten *et al*. 1996), only 16.39% of Java's original forest cover remains, of this, 9.51% comprises production forests and 6.88% combined protection and conservation forests (KLHK 2018). Nijman (2013) indicated that forest fragments, and especially montane areas, total about 10% of the island. Grizzled langurs can still be found in some lowland forests (Nijman and van Balen 1998; Nijman 2017), but priorities for the conservation of this species have focused on montane areas (Supriatna *et al.* 1994). Nijman (2017) listed all the large remaining populations of P. *comata* by altitude.

Population density estimates for the grizzled langurs have mostly been conducted in strictly protected areas (Ruhiyat 1983; Melisch and Dirgayusa 1996; Tobing 1999; Heriyanto and Iskandar 2004; Kartono *et al*. 2009; Nijman 2017), few in production forests. Information about the factors that determine population density is particularly important in developing effective conservation strategies (Chapman *et al.* 2004; Mbora and Meikle 2004; Agetsuma *et al*. 2015). There have been numerous studies on such factors for primate populations (for example, Ross and Srivastava 1994; Wich *et al.* 2004; Ray *et al.* 2015) but few for the Javan grizzled langurs. Kartono *et al.* (2009) looked at the effect of the density of some tree species on the numbers of grizzled langurs in the forest of Gunung Ciremai National Park. A study conducted by Nijman (2017) examined the relationship between group size and altitude and other environmental variables.

Many factors affect population density of primates. In this study we examined the availability of food sources (Mammides *et al.* 2008; Pozo-Montuy *et al.* 2011; Kankam and Sicote 2013), spatial attributes (Estrada and Coates-Estrada 1996; Arroyo-Rodríguez *et al.* 2008), and habitat disturbance (Chapman *et al.* 2007). This study aimed at (1) estimating the population density of grizzled langurs, (2) identifying the factors that determine the population density of this monkey in production forests, and (3) discussing the conservation implications. We proposed that the number of tree species and food trees, and food density would have a positive effect on the population of grizzled langurs, while the density of other primates occupying the same habitat would have a negative effect. We also predicted that population density would decrease with a) increasing distance of the survey sites to more extensive, remote areas, and b) decreasing distance from research site to the nearest road. Greater forest disturbance indicated by higher tree stump density was also expected to negatively affect population density. This information on the factors that influence the population density could help to promote more favorable conditions for grizzled langur conservation in production forests.

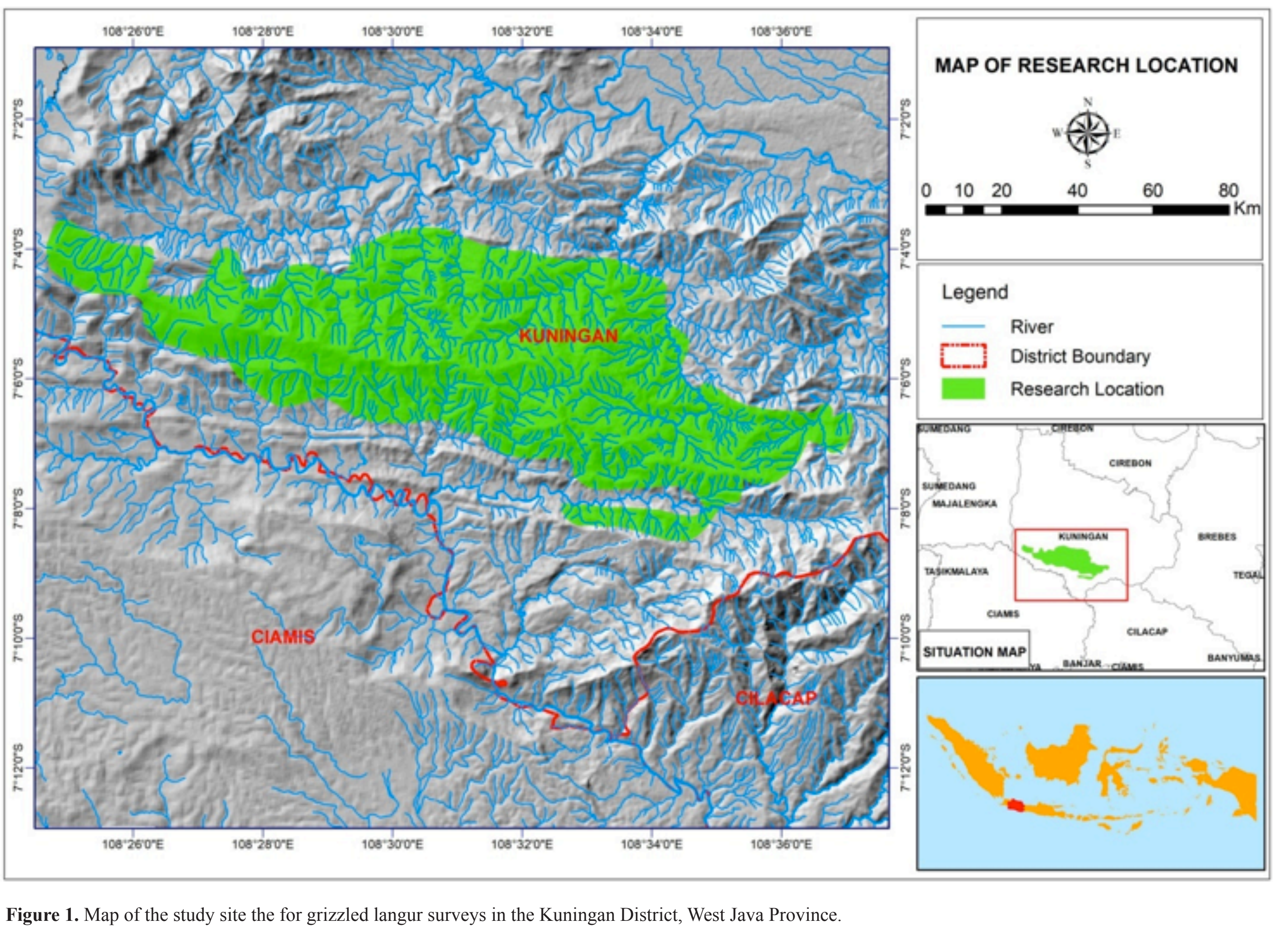

Figure 1. Map of the study site the for grizzled langur surveys in the Kuningan District, West Java Province.

Methodology

Study area

We conducted this research in 19 forest patches in the Bukit Pembarisan forest in Kuningan District (108°23'−108°47'E and 6°47'−7°12'S) (Fig. 1), West Java Province, Indonesia. Annual rainfall in this district is 1,000-4,000 mm (Bappeda Kuningan District 2015). Our research site was a production forest with a total area of 52.57 km². Land use there was a combination of mixed farms, plantations and natural forest remnants (Prasetyo *et al.* 2012). Mixed farms are managed by communities on private land, planted with commercial tree species and fruit-crops, such as sengon (*Paraserianthes falcataria*), mahogany (*Swietenia mahagoni*), jabon (*Anthocepalus cadamba*), teak (*Tectona grandis*), mango (*Mangifera indica*), bitter bean (*Parkia speciosa*), coconut (*Cocos nucifera*), jackfruit (*Artocarpus heterophyllus*), and melinjo (*Gnetum gnemon*) (Prasetyo *et al.* 2012). Planted production forests on state land were managed by PT Perhutani under Kuningan Forest Management Units (FMU). They were generally teak or pine monocultures. Forest remnants were also part of the production forest, scattered randomly and allocated as local protected areas due to steep or very steep topography. The remnant natural forests in lowland and hilly areas were disturbed in the past, and are mostly bordered, or surrounded, by mixed farms and plantations.

Besides *P. comata*, we observed long-tailed macaques (*Macaca fascicularis*), ebony langurs (*Trachypithecus auratus*), and the Javan slow loris (*Nycticebus javanicus*). We never saw Javan gibbons (*Hylobates moloch*). Data were collected on *M. fascicularis* and *T. auratus* considering that their numbers may be influencing the size of the grizzled langur population. *Trachypithecus auratus* is folivorous (Kool 1993) and *M. fascicularis* includes leaves in its diet when other food sources are scarce.

Surveys

We carried out line transect surveys in the forest patches indicated by the villagers, following Martins (2005) and Greenwood and Robinson (2006). This method has been widely used to estimate primate population densities (Brugiere and Fleury 2000; Hoing *et al.* 2013). The location of the survey transects was not chosen randomly or systematically (we followed the villager's advice as to where the langurs (Figure 2) could be found), so it is not possible to deduce an overall population density for the production forest.

Surveys were carried out in the morning, from around 06:00 until around 12:00 h. We used already existing trails or paths that we cut prior to the survey, taking into account the distance between the trails to avoid double counting (Estrada and Coates-Estrada 1996). We walked slowly but the time spent on each trail varied due to the topography and the density of the vegetation. The direction of the transect had to be

Figure 2. Javan Grizzled langur (*Presbytis comata*) found in the study sites, in Kuningan District, West Java Province.

Table 1. Number and length of line transects in 19 study sites in Kuningan District, West Java, Indonesia.

No.	Sites	Number of line transects	Length of line transects (km)
1	Bagawat	3	5.0
2	Gunung Aci	5	5.1
3	Kutawaringin	4	5.1
4	Subang	4	5.1
5	Jalatrang	3	5.1
6	Jamberama	3	5.5
7	Padahurip	3	5.0
8	Cilebak	3	5.0
9	Cikondang	4	5.0
10	Tundagan	3	5.4
11	Pasir Agung	4	5.1
12	Citapen	4	5.0
13	Cipedes	5	6.1
14	Pinara	5	5.3
15	Gunung Manik	5	5.5
16	Cijemit	4	5.8
17	Pamulihan	4	5.0
18	Karangkancana	4	6.0
19	Patala	2	5.3
	Total	72	100.3

deflected when confronting obstacles such as ravines or cliffs, but the overall direct was maintained.

The length of the line transects at each site varied from 5.0 to 6.1 km (Table 1). The lengths were measured using a hipchain, and each transect was walked once. The transect widths used for estimating the density of the three species encountered was the effective width and was obtained after all data for each species had been entered into Distance 5.0. They were: 2×36.16 m for *P. comata*, 2×33.96 m for *T. aurata*, and 2×51.20 m for *M. fascicularis*. We recorded the size and, when possible, the composition of each group, the distance from the observer to the first individual seen (using a Nikon Forestry Rangefinder), the activities of the group, the species of tree in which the first individual was seen and its coordinates (using a Garmin GPSmap 60Csx), the angle (θ) of the group to the position of the observer, and the direction they were moving (Eisenberg *et al.* 1981). Observation time varied and was terminated when each individual in the group had been identified accurately or observers agreed to an estimated group size (Anderson *et al*. 2007; Pozo-Montuy *et al.* 2011). Data collection was assisted by two trained field assistants.

Habitat attributes

We recorded habitat attributes in sample plots of 20 m × 20 m placed every 100 m along each trail (Kusmana and Istomo 1995; Soerianegara and Indrawan 2005). Habitat characteristics considered included the number of tree species (Ross and Srivastava 1994; Kankam and Sicote 2013), the number of food tree species (Pozo-Montuy *et al.* 2011), tree density (Ross and Srivastava 1994; Wieczkowski 2004), and food tree density (Anderson *et al.* 2007). For each tree in the plot, we recorded the species and the diameter at breast height for those with diameters ≥10 cm, large enough to be of use to the langurs (Ruhiyat 1983; Gunawan *et al.* 2008; Onderdonk and Chapman 2000; Worman and Chapman 2006). We took botanical samples of those trees that we were unable to recognize, and they were subsequently classified by botanists at the Bogoriense Herbarium of the Indonesian Institute of Sciences. We observed grizzled langurs eating the leaves and fruits of some of the species. Villagers, who knew the monkeys and their feeding habits well, also provided valuable information on which species they feed from, and we also consulted Ruhiyat (1983), Farida and Harun (2000) (two studies in montane forest) and Melisch and Dirgayusa (1996), who listed species included in their diet elsewhere.

Spatial attributes

The study also included some spatial attributes that we predicted might influence the population density. The variables were the distance from each of the 19 sites to the nearest undisturbed forest (Estrada and Coates-Estrada 1996; Pozo-Montuy *et al*. 2011) and the distance from the transects to the nearest settlement and road (Arroyo-Rodríguez *et al.* 2008). The distance of each transect to a larger undisturbed forest edge was obtained by measuring the average distance from coordinates of the initial point of the line transect and projecting the distance using Google Earth Map. A similar method was used to obtain the distance from each location to the nearest road and settlement.

Habitat disturbance

A surrogate for habitat disturbance and a measure of the intensity of past logging was tree stump density (Wood and Gillman 1998). Logging was expected to negatively affect the density of primates (Chapman *et al.* 2007). Data were collected in parallel with vegetation data in the sample plots. Only stumps without signs of decay were recorded.

Data Analysis

We estimated the total population density and the density at each site to identify the controlling factors of the population density. To estimate the group density of the entire area surveyed we used the following equation (Martins 2005): D = number of groups seen /2(ESW)L, where D = grizzled langur group density (group/km²), ESW = effective strip width (m), and L = total line transect (km). The ESW value was obtained using Distance 5.0. The population density was obtained by multiplying the group density by the average group size (Martins 2005; Fashing *et al.* 2012). Estimates of population density in each transect were also calculated using the same formula with the number of groups in each transect, transect length, and the average size of groups in each location. We rarely found more than one group along any one transect, thus we used one ESW value for transects. The same technique

Table 2. Descriptive statistic and Kolmogorov-Smirnov test of habitat and other factors influencing grizzled leaf monkey in production forest of Kuningan District (all based on 19 forest divisions).

Variable	Mean	SD	Kolmogorov-Smirnov test	
			Z	P
Ebony langur population density (individuals/km^2)	144.16	103.51	0.517	0.952
Long tailed macaque density (individuals/km^2)	40.47	74.67	1.281	0.075
Number of food tree species (species/ha)	22.21	4.25	0.717	0.683
Food tree density (individuals/ha)	158.24	43.88	0.798	0.548
Stump density (individuals/ha)	2.10	3.19	1.126	0.159
Research site distance to the nearest road (km)	0.59	0.38	0.699	0.713
Research site distance to the nearest forest area (km)	12.57	6.42	0.549	0.924

was used to estimate the population densities of ebony langurs and long-tailed macaques.

Habitat characteristics were analyzed and compared by means and standard deviations. Variables that predicted grizzled langur population densities were identified in three stages. We first analyzed the data distribution using the Kolmogorov-Smirnov test. Data is normally distributed if $p>0.05$. We then ran a Pearson Correlation test among all independent variables at $p \leq 0.05$ (Anzures-Dadda and Manson 2007; Arroyo-Rodríguez *et al.* 2008). In the multiple regression, the number of tree species was excluded from the analysis due to a significant correlation with the number of food tree species ($r = 0.90$; $p<0.001$). Total tree density was excluded due to its correlation with food tree density ($r = 0.58$; $p = 0.009$) and tree stump density ($r = 0.46$; $p = 0.050$). The distance of the site to the nearest settlement was also excluded because of the strong correlation with distance to the nearest road and forest area ($r = 0.94$; $p <0.001$, $r = 0.46$; $p = 0.048$, respectively). Stepwise multiple linear regression in SPSS 21 was used to identify the components of the habitat that significantly influenced population density (Mbora and Meikle 2004). The significance level used was (α) ≤ 0.05. The contribution of combined variables to population density was calculated as an R2 value.

Results

Population density

We conducted this study in 19 forest divisions with a total line transect length of 100.3 km (Table 1). The total population of grizzled langurs from both the line transects and nearby areas was 486 in 65 groups. The relative abundance was calculated based on 41 groups located on the line transects—0.41 groups/km of transect. We used Distance ver.5.0 to estimate a group density of 5.66 groups/km² (min = 4.68 groups/km²; max = 6.85 groups/km²). We estimated the population density to be 44.71 individuals/km² (min = 36.97 individuals/km²; max = 54.12 individuals km²), calculated by multiplying the mean group size by group density. The mean group size used was 7.9 (Nijman 2017).

Habitat characteristics

Data on habitat characteristics was collected from 19 forest divisions, comprising 1003 plots. Data of all measured variables were normally distributed. Descriptive statistics and Kolmogorov-Smirnov test of the seven variables estimated to control population density are presented in Table 2.

Factors controlling population density

Our study revealed that two out of seven variables were significantly related to grizzled leaf monkey density in this production forest—the number of food tree species and stump density. The effects of each variable were contradictory (Table 3). The number of food tree species showed a significant positive relationship with the monkey population while increasing stump density significantly associated with a decrease in the monkey population. Increasing stump number indicates increasing forest disturbance. Both variables explain 40% variability of the monkey population density (R2 = 0.40; $F = 5.33$; $p = 0.017$). There was, however, no significant relationship ($p>0.05$) between population density and other measured variables, including food tree density,

Table 3. Variables significantly related to *Presbytis comata* population density.

Model	Constant (SE)	T	P
Constant	-60.92 (43.28)	-1.408	0.178
Number of food tree species (species/ha)	5.32 (1.94)	2.739	0.015
Stump density (individuals/ha)	-5.79 (2.59)	-2.237	0.040

langur population density, and the distance of the transects to the nearest road and forest. Thus, we suggest that number of food tree species and stump density are good predictors in estimating the population density of *P. comata*.

Discussion

Previous population studies have been conducted mainly in conservation areas and, in adding data on a production forest, we suggest that our results will be helpful in obtaining better estimates of the grizzled langur population on Java. We recorded 486 animals and suggest that this will increase our current estimate of the total population. A recent estimate for the grizzled langur population on Java, based on 11 areas surveyed, was 1,760–2,360 groups, which, with an average group size of just over seven, translates to between 13,000 and 17,000 individuals (Nijman 2017). Our results also provide information on factors affecting the monkey population. The population was influenced by food availability and habitat disturbance from human activities. Forests with a high diversity of food tree species have higher densities, and lower population densities are associated with higher levels of logging or timber harvesting.

It is difficult to compare this study with others as so few have been done, and none previously in a production forest. We can only compare our results with surveys in conservation forests. We found similar population densities to those of grizzled langurs in Situ Patenggang Nature Reserve (Ruhiyat 1983). However, our results were eleven and six times higher than the densities of this species in Ujung Kulon National Park and Gunung Ciremai National Park, respectively (Heriyanto and Iskandar 2004; Kartono *et al.* 2009). Group densities of this species in the Dieng Mountains have been found to range from 1.2 to 4.4 groups/km² (Nijman and Nekaris 2013). Combining the results of previous studies, group density ranges from 0.4 to 0.6 groups/km² in lowland forest and 0.5 to 2.4 groups/km² in hill forest (Nijman 2017). Our estimate is higher and, while we lack sufficient information to say why, it is possible that different methods and habitat quality could be involved. Nevertheless, this study provides the first evidence of the significant contribution of a production forest in supporting this population of grizzled langurs that have been ranked as Endangered on the IUCN Red List since 1988 (Nijman and Richardson 2008). The identification of further potential habitats and populations such as at this site, will be imperative for the conservation of this species.

Lowland forests have been identified as the grizzled langur's principal habitat (Hoogerwerf 1970), most likely due to the diversity of food tree species available. Variation in tree species density results in variation in food availability and habitat quality (Li 2004; Arroyo-Rodríguez and Mandujano 2006). A positive correlation between the number of species of food trees and the *P. comata* population in our study showed the importance of food source variability in the survival of this species. In Gunung Merbabu National Park, grizzled langurs were found mostly in forests with a high plant species diversity providing for a more diverse diet (Handayani and Latifiana 2019). There, Kusumanegara *et al.* (2017) frequently recorded grizzled langurs in areas close to the forest edge, but they did not associate this with possible differences in food tree diversity between the edge and the interior of the forest. In Kartono *et al.*'s (2009) study in Gunung Ciremai National Park, the population density was found to be affected by the density of nine tree species, namely: *Podocarpus neriifolius*, *Saprosma arborea*, *Glochidion arborescens*, *Palaquium impressinervium*, *Ficus* sp., *Psychotria* sp., *Litsea sanguinolenta*, *Lithocarpus ewyckii*, and *Lithocarpus sundaicus*. Previous studies, including, for example, *Presbytis kirkii* in Zanzibar (Siex and Struhsaker 1999) and *P. rubicunda* in the di Sepilok Nature Reserve, Malaysia (Davies *et al*. 1988) are in agreement with our findings. Cristobal-Azkarate and Arroyo-Rodríguez (2007) reported that howler monkey (*Alouatta palliata*) population densities depend on a number species of food tree. In Cabeza del Toro and the Santuario Nacional Cordillera de Colan, Peru, the occupancy probability of the Peruvian night monkey *Aotus miconax* is positively correlated with the diversity of the vegetation (Campbell *et al.* 2019). Based on our and other previous studies, it is evident that enriching the tree species diversity in production forests would be a valuable conservation tool for theses primates.

Ultimately, population density is likely determined by the nutritional benefits of a diverse diet provided by high tree species diversity (Cristobal-Azkarate *et al.* 2005; Chapman *et al.* 2012). The main source for the colobines is leaves (Ruhiyat 1983; Kirkpatrick 1999; Wasserman and Chapman 2003), and the leaves of each tree species differ in their nutritional and energetic value (Farida and Harun 2000; Nelson *et al*. 2000; Wasserman and Chapman 2003; Hockings *et al.* 2009). *Albizia falcataria*, for example, has higher protein (26.34%) and energy (5.17 kcal/gram) compared to *Ficus padana* with a protein content of 14.64% and energy value of 4.69 kcal/gram. *Albizia falcataria* leaves have a lower fat content (0.96%) than those of *F. padana* (2.93%) (Farida and Harun 2000). Grizzled langurs also eat fruit (Ruhiyat 1983), available at different times of the year depending on the species (Koenig *et al.* 1997; Hockings *et al.* 2009) and likewise variable in their nutrient content (Milton 2003; Wasserman and Chapman 2003). Primates require diverse diets to support reproduction, growth and development (Koenig *et al.* 1997; Felton *et al.* 2009; Chaves *et al*. 2011, Chapman *et al.* 2012).

Populations were lower in sites with a high tree stump density reflecting the extent of logging. Other studies have also found this correlation: Galago demidovii, G. inustus, and Perodictus potto in Kibale forest (Weisenseel *et al.* 1993), chimpanzees, *Pan troglodytes verus*, in western Equatorial Africa (Morgan and Sanz 2007), and Procolobus pennantii and *Colobus guereza* in western Uganda (Chapman *et al.* 2007). Logging has been responsible for the decline of Lophocebus albigena group density in Kibale National Park in Uganda (Chapman *et al.* 2000). Negative effects of logging are observed for gorilla populations in Congo resulting from facilitated access for poachers (Haurez *et al*. 2013). Logging, of course, is the objective of production forests, and it is important to further examine the effect of logging intensity in order to ensure the sustainability of the primate populations there.

Grizzled langurs are shy (Ruhiyat 1983) and avoid interactions with humans (Tobing 1999; Nijman and Nekaris 2013). The disturbance created by logging and the sound of chainsaws inevitably result in the monkeys moving to other locations and Tobing (1999) has shown that in Gunung Halimun National Park the populations density is lower in disturbed forests. Li (2004) reported decreasing population densities of snub-nosed monkey (*Rhinopithecus roxellana*) as a result of human disturbance in Shennongjia Nature Reserve in China.

Our hypothesis was that food tree density will positively correlate to the grizzled langur population in accordance with the findings of studies on *Procolobus rufomitratus*, *Pan troglodytes*, and *Alouatta pigra* (Balcomb *et al.* 2000; Mbora and Meikle 2004; Pozo-Montuy *et al.* 2011). Our preliminary hypothesis was that east Javan langur, *Trachypithecus auratus*, and long-tailed macaque, *Macaca fascicularis* densities would negatively influence those of the grizzled langur due to overlap in their diets (Kool 1992; Kool 1993; Yeager 1996). Our results did not reveal this, however. No response of food tree density on the monkey population implied that food availability was the limiting factor (Yeager and Kirkpatrick 1998). We suspect that the grizzled langur is distinct in its use of different food sources, as has been shown, for example, for Peter's Angolan colobus, *Colobus angolensis palliatus* (v. Anderson *et al*. 2007).

Asian colobines can consume young and old leaves (Yeager and Kirkpatrick 1998). Leaves are a relatively stable and abundant food (Chapman 1990), and grizzled langur populations are probably well below the environmental carrying capacity (Yeager and Kirkpatrick 1998). No direct competition was observed between grizzled langurs and *T. auratus* and *M. fascicularis*.

We also examined the relationship of population density and the distance of the transects to the nearest road, assuming that this represents the proximity of nearest community settlement. Arroyo-Rodríguez *et al.* (2008) reported that the proximity of settlements and the occupation of forest patches by Mexican howler monkeys, *Alouatta palliata mexicana*, were positively correlated; the further away the settlement, the more likely the forest was occupied by howlers. Our results, however, indicate a different response, perhaps due to less intense human activity. A lack of correlation of grizzled langur population density to the nearest road indicated that this variable has yet to be a threat—the monkeys, it seems, tolerate road traffic and human activities.

This study was carried out in one forest landscape in one district, and similar surveys are needed in other parts of the species' range to establish a more robust estimate of population density and the controlling factors. Our results only explained less than 50% of population variability. Further research should consider a larger study site, and linear transects rather using available paths in the site, and increasing the measurement of environmental variables including such as lianas as food sources (Ruhiyat 1983) and nutritional content, protein and fiber, of their foods.

Conservation approaches can be tested at government-owned plantations (PT Perhutani), mixing commercial species with food tree species, including pulai (*Alstonia scholaris*), saninten (*Castanopsis argentea*), kondang (*Ficus glomerata*), walen (*Ficus ribes*), beunying (*Ficus* sp.), kareumbi (*Omalanthus populneus*), pasang (*Quercus* sp.), and peutag (*Syzygium lineatum*) (Ruhiyat 1983). In such agroecosystems, in addition to planting food tree species, it would be possible to increase the proportion and number of multipurpose trees, including those providing non-timber forest products, along with cloves, coconut, mango, mangosteen, melinjo, rambutan, nutmeg, and guava. This enrichment of forests low in food tree species could expand the habitats suitable for the grizzled langurs because the species can only survive in forest >50 km² (Nijman 2013). Nonetheless, population management of grizzled monkey populations in production forests, including mixed farms, requires more in-depth studies that involve relevant stakeholders to sustain both conservation and economic benefits.

Variability of food tree species and the level of forest disturbance due to logging were the controlling factors of grizzled leaf monkey population. Conservation efforts for grizzled langurs should consider these environmental variables. Balancing the proportion of commercial tree species with sufficient food tree species will contribute to supporting populations of the grizzled langur, while also ensuring the economic health of the timber companies. With further research, we suggest that this approach can be replicated in other production forests.

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Appendix

List of food tree species for *Presbytis comata* in 19 sites in Kuningan District, West Java, Indonesia.

No.	Scientific name	Family
1	*Aglaia argentea* Blume	Meliaceae
2	*Aglaia odorata* Lour.	Meliaceae
3	*Aglaia* sp.1	Meliaceae
4	A*langium rotundifolium* (Hassk.) Bloemb.	Cornaceae
5	*Albizia falcataria* (L.) Fosberg	Leguminosae
6	*Albizia procera* (Roxb.) Benth	Leguminosae
7	*Aleurites moluccana* (L.) Willd.	Euphorbiaceae
8	*Alseodaphne umbelliflora* Hook.f.	Lauraceae
9	*Alstonia scholaris* R. Br.	Apocynaceae
10	*Antidesma bunius* (L.) Spreng	Phyllanthaceae
11	*Antidesma montanum* Blume	Phyllanthaceae
12	*Archidendron pauciflorum* (Benth.) Nielsen	Leguminosae
13	*Arthrophyllum diversifolium* Blume	Araliaceae
14	*Artocarpus elastica* Reinw.	Moraceae
15	*Artocarpus heterophyllus* Lam.	Moraceae
16	*Baccaurea javanica* Muell. Arg.	Phyllanthaceae
17	*Bischofia javanica* Blume	Phyllanthaceae
18	*Blumeodendron tokbrai* (Blume) Kurz	Euphorbiaceae
19	*Bridelia monoica* Merr.	Phyllanthaceae
20	*Calliandra calothyrsus* Meisn.	Leguminosae
21	*Cananga odorata* (Lamk.) Hook.	Annonaceae
22	*Canthium glabrum* Blume	Rubiaceae
23	*Cassia siamea* Lamk	Leguminosae
24	*Castanopsis argentea* A. DC.	Fagaceae
25	*Castanopsis tungurrut* A. DC.	Fagaceae
26	*Ceiba pentandra* L. Gaertn.	Bombacaceae
27	*Cinnamomum burmannii* (Nees & T.Nees) Blume	Lauraceae
28	*Cinnamomum iners* Reinw. ex Blume	Lauraceae
29	*Coffea* sp.	Rubiaceae
30	*Croton argyratus* Blume	Euphorbiaceae
31	*Cryptocarya ferrea* Blume	Lauraceae
32	*Dalbergia latifolia* Roxb.	Leguminosae
33	*Dillenia indica* L.	Dilleniaceae
34	*Diospyros macrophylla* Blume	Ebenaceae
35	*Dracontomelum dao* Merr. & Rolfe	Anacardiaceae
36	*Dysoxylum macrocarpum* Blume	Meliaceae
37	*Elaeocarpus glaber* Blume	Elaeocarpaceae
38	*Erythrina lithosperma* Miq.	Leguminosae
39	*Eurya acuminata* DC.	Pentaphyllaceae
40	*Ficus ampelas* Burm.f.	Moraceae
41	*Ficus fistulosa* Reinw. ex Blume	Moraceae
42	*Ficus magnoliaefolia* Blume	Moraceae

43	*Ficus padana* Burm.f.	Moraceae
44	*Ficus ribes* Reinw	Moraceae
45	*Ficus septica* Burm. F.	Moraceae
46	*Ficus sumatrana* Miq.	Moraceae
47	*Ficus variegata* Blume	Moraceae
48	*Flacourtia rukam* Zoll.& Mor.	Salixaceae
49	*Garcinia parvifolia* (Miq.) Miq.	Clusiaceae
50	*Geunsia pentandra* Merrill	Lamiaceae
51	*Gironniera cuspidata* (Blume) Kurz	Canabaceae
52	*Gliricidia sepium* H.B.K.	Leguminosae
53	*Glochidion arborescens* Blume	Phyllanthaceae
54	*Glochidion philippicum* (Cav.) C.B. Rob.	Phyllanthaceae
55	*Gnetum gnemon* L.	Gnetaceae
56	*Grewia laevigata* Vahl	Malvaceae
57	*Hibiscus macrophyllus* Roxb. ex Hornem	Malvaceae
58	*Homalanthus populneus* (Giesel.) Pax	Euphorbiaceae
59	*Knema cinerea* Warb.	Myristicaceae
60	*Lansium domesticum* Corr	Meliaceae
61	*Leucaena leucocephala* (Lam.) de Wit	Leguminosae
62	*Macaranga tanarius* (L.) M.A.	Euphorbiaceae
63	*Macaranga triloba* (Reinw.ex Blume) Muell. Arg.	Euphorbiaceae
64	*Macropanax dispermus* (Blume) O.K.	Araliaceae
65	*Maesopsis eminii* Engl.	Rhamnaceae.
66	*Mallotus* sp.1	Euphorbiaceae
67	*Mangifera foetida* Lour	Anacardiaceae
68	*Mangifera longipes* Griff.	Anacardiaceae
69	*Melia azedarach* L.	Meliaceae
70	*Melicope lunu-akenda* (Gaertn.) T.G. Hartley	Rutaceae
71	*Meliosma ferruginea* Blume	Sabiaceae
72	*Melochia umbellata* (Houtt.) Stapf.	Malvaceae
73	*Michelia velutina* DC	Magnoliaceae
74	*Nauclea orientalis* L.	Rubiaceae
75	*Neonauclea obtusa* (Blume) Merr.	Rubiaceae
76	*Nephelium lappaceum* L.	Sapindaceae
77	*Oreocnide rubescens* (Blume) Miq.	Urticaceae
78	*Ostodes paniculata* Blume	Euphorbiaceae
79	*Pangium edule* Reinw.	Achariaceae
80	*Paraserianthes falcataria* (L.) Nielsen	Leguminosae
81	*Paratocarpus venenosa* (Z.& M.) Becc.	Moraceae
82	*Parkia javanica (Lam.)* Merr.	Leguminosae
83	*Parkia speciosa* Hassk.	Leguminosae
84	*Persea americana* P. Mill.	Lauraceae
85	*Persea rimosa Zoll.* ex Meisn.	Lauraceae

86	*Piper aduncum* L.	Piperaceae
87	*Pittosporum ramiflorum* Zoll. ex Miq.	Pittosporaceae
88	*Planchonia valida* Blume	Lecythidaceae
89	*Platea excelsa* Blume	Icacinaceae
90	*Radermachera gigantea (Blume) Miq.*	Bignoniaceae
91	*Samanea saman* (Jacq.) Merr.	Leguminosae
92	*Saurauia bracteosa* DC.	Actinidiaceae
93	*Saurauia reinwardtiana* Blume	Actinidiaceae
94	*Schima wallichii (DC.)* Korth.	Theaceae
95	*Schleichera oleosa* Merrill	Sapindaceae
96	*Sterculia oblongata* R. Br.	Malvaceae
97	*Symplocos fasciculata* Zoll.	Symplocaceae
98	*Syzygium lineatum (DC.)* Merr. & Perry	Myrtaceae
99	*Syzygium polyanthum* Wigh Walp.	Myrtaceae
100	*Tabernaemontana sphaerocarpa* Blume	Apocynaceae
101	*Terminalia belirica* (Gaertn.) Roxb.	Combretaceae
102	*Toona sureni* (Blume) Merr.	Meliaceae
103	*Turpinia sphaerocarpa* Hassk.	Staphyleaceae
104	*Vernonia arborea* Buch. - Ham.	Compositae
105	*Vitex pinnata* L.	Lamiaceae
106	*Xanthophyllum excelsum* (Blume) Miq.	Polygalaceae