PWS Yakushima Field Science Course 2018
Monkey Group - Scientific Report

The influence of human activities and elevation on the distribution of Yakushima macaques (*Macaca fuscata yakui)*

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Introduction

To improve conservation efforts for Japanese macaques, a thorough understanding of a particular macaque population, and especially their geographical distribution, is essential. Primates' population state is impacted by the habitat quality represented by the vegetation type and the habitat disturbance (Takasaki, 1981). In recent years, Japanese macaques' habitat quality has been greatly affected by human activities such as artificial feeding, hunting and capture (Yamagiwa & Hill, 1998).

Japan is famous for its ecological hotspots and diversity. As a result, the country is home to many unique species, especially in its ecologically isolated island habitats, such as Japanese macaques (*Macaca fuscata*). Therefore, extensive research on such species is crucial to informing conservation efforts and minimizing conflicts with nearby human activities. Japan's isolated habitats provide an optimal setting in which to perform research on Japanese macaques and their interactions with humans.

One example of such an island is Yakushima, which is located in southern Kyushu, Japan. It has a total area of nearly 505 km². Many types of landscapes and species exist on Yakushima, partly due to the large range of elevational changes throughout the island which can reach up to 1,936 meters. The lower areas of Yakushima consist of subtropical warm-temperate forests and some higher points consist of subalpine grasslands (Agatsuma, 1996). The forests cover over 90% of the island and are surrounded with farmlands which encircle the coast (Miyabayashi, 1982). Logging remained the primary industry of Yakushima and reached its peak in 1962, which prompted the government to enact legislation to protect the island's forests (Agatsuma, 1996). Consequently, logging has been gradually decreasing by 1982 (Miyabayashi, 1982).

Although research on macaque distribution and human activities on Yakushima has been performed separately, little research has been conducted about the relationships between them (Hayaishi & Kawamoto, 2006). The Yakushima macaque *(Macaca fuscata yakui)* is a subspecies of the Japanese macaque that is endemic to Yakushima. Researchers have studied the macaques living on the island for decades. For example, one study investigated the effects of seasonal changes of food and temperature on macaque activity in the island's coniferous forests (Hanya, 2004). Other researchers have performed censuses focused on the western coastal area where natural vegetation remains undisturbed (Yoshihiro et al., 1999). However, many areas in Yakushima were historically impacted by logging, and agriculture continues to be a common practice on the island today (Yamagiwa, 2008). The distribution of macaques in habitats disturbed by such practices is not well known. The purpose of this field survey was to investigate the potential influence of human activity on the distribution of Yakushima macaques. We explored how different land use areas such as plantation and cropland, as well as how the distance from villages and elevation, may have an influence on macaque presence.

Methods

Study site and data collection

Our study was conducted in Yakushima Island, Kagoshima Prefecture, Japan. Research on monkeys in this site was first conducted in 1952 and it was not until mid-1970s that field studies resumed (Yamagiwa, 2008). Japanese macaques in Yakushima are not provisioned by humans and they mainly feed on natural food resources.

From May 20 to May 22, 2018, we conducted route censuses along forest roads in Yakushima to investigate the distribution of macaques. During route censuses we recorded and geotagged the locations of direct macaque observations, feces and vocalizations by GPS (Garmin Etrex 20x, US, Figure 1). Trackpoints were automatically recorded at 100m intervals during our route censuses.

Data analyses

We classified the vegetation of Yakushima into four categories; forest, plantation, cropland, and others (Figure 1). Vegetation data were obtained from GIS data of 1:25,000 scale vegetation map created by Ministry of the Environment of Japan (6th and 7th National Basic Survey on Natural Environment; Biodiversity Center of Japan, Ministry of the Environment).

We connected adjacent trackpoints with lines and drew polygonal lines for each road. We segmented these polygonal lines into 500m replicates and calculated the proportion of land area covered with forest, plantation and cropland within the radius of 250m around the middle points

of each segment (Figure 2). We also recorded the elevation of each middle point and the distance between each middle point and the villages. Villages included cropland and city area.

In order to investigate the effect of human activity and elevation on the distribution of Japanese macaques in Yakushima, we used a generalized linear model (GLM) assuming binomial distribution and a logit link function. We set the presence of monkeys (Yes/No) within the radius of 250m around the middle points of each segment as a response variable. We initially set elevation, distance from villages and the proportion of land area covered with forest, plantation and cropland as explanatory variables. However, variance inflation factors (VIFs) of the proportion of plantation and cropland were over 5 (plantation: 9.36; cropland: 11.05) which indicated multicollinearity in the model, so we decided to conduct two GLMs. Although both models included elevation, distance from villages and proportion of forest as explanatory variables, the first model (model 1) included the proportion of plantation, and the second model (model 2) included the proportion of cropland as an additional explanatory variable. VIFs in these models were all less than 2.5.

We processed all GPS data with QGIS software (QGIS Development Team, 2016) and GLM analyses were conducted using R (R Core Team, 2016). We set $\alpha = 0.05$.

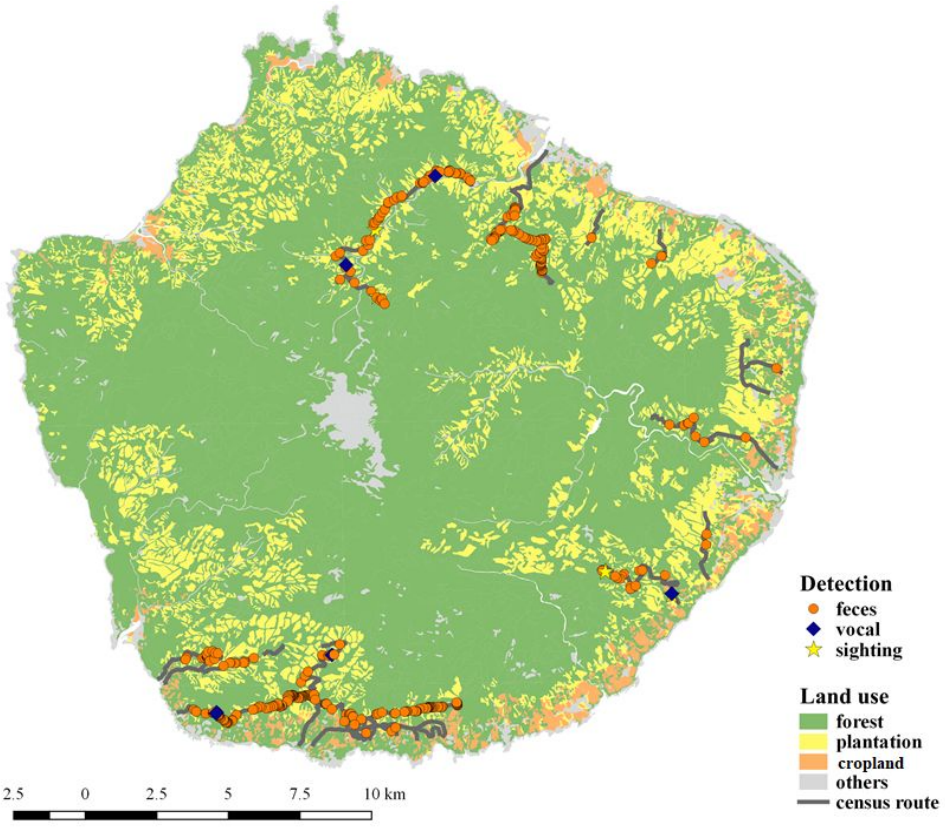

Figure 1. All census routes and detection points in our study.

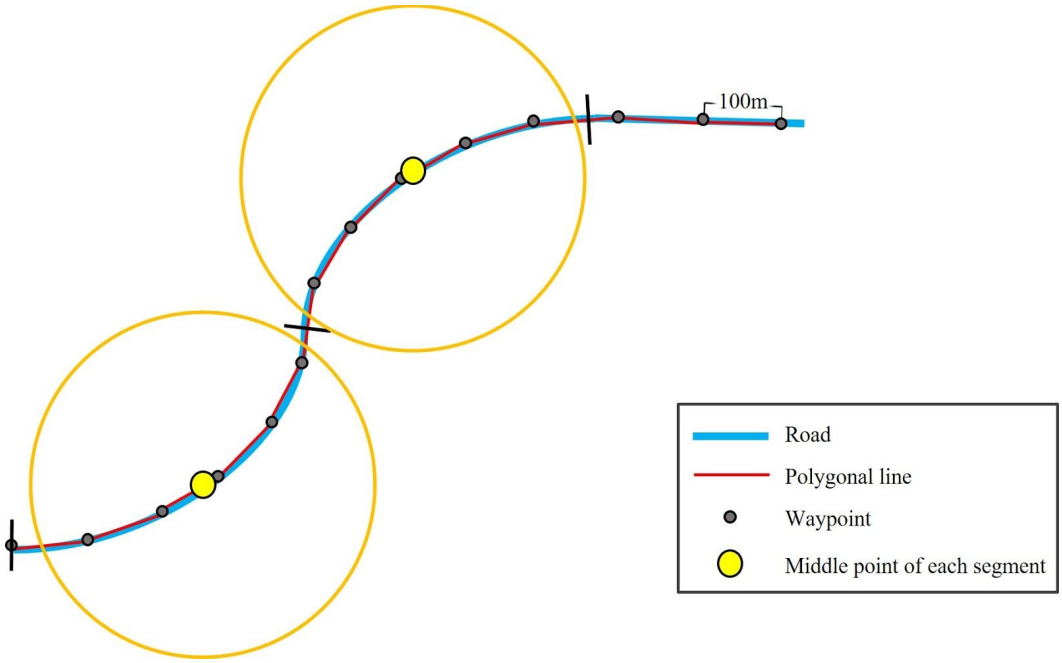

Figure 2. Segmentation of routes into 500m replicates. We drew a circle with a radius of 250m around the middle point of each segment, then calculated the proportion of land area covered with forest, plantation and cropland within each circle.

Results

We detected 402 feces, 8 calls and 5 direct sighting during our route censuses . The roads walked during censuses and the location of all detections are shown in Figure 1.

The results of the GLMs are shown in Table 1. These results indicate that macaques tended to be detected far away from villages, although it was statistically significant only in model 2 (model 1: $\beta = 4.62\times10^{-4}$, $p = 0.051$; model 2: $\beta = 4.81\times10^{-4}$, $p < 0.05$). The proportion of forest had a significant effect on the distribution of Japanese macaques in both models (model 1: -6.56×10^{-2}, $p < 0.01$; model 2: $\beta = -7.47\times10^{-2}$, $p < 0.01$). This indicates that macaques tended to be detected in areas where the proportion of forest was low. In model 1, the proportion of plantation land use significantly affected the distribution of macaques ($\beta = 1.80\times10^{-2}$, $p < 0.05$). This indicates that monkeys were more likely to be detected in areas where the proportion of plantation was high. Elevation and the proportion of cropland did not show any significant effect on the distribution of macaques (Tab. 1).

Table 1. Results of Generalized Linear Models.

Explanatory variables	Estimates	SE	z	p (>|z|)
model 1				
Intercept	−1.07	0.56	−1.91	0.056
Elevation	-9.28×10^{-4}	1.42×10^{-3}	−0.65	0.51
Distance from villages	4.62×10^{-4}	0.24×10^{-4}	1.95	0.051
Proportion of forest	-6.56×10^{-2}	2.27×10^{-2}	−3.21	**0.0038****
Proportion of plantation	1.80×10^{-2}	8.77×10^{-3}	2.29	**0.040***
model 2				
Intercept	0.26	0.50	0.52	0.60
Elevation	-5.87×10^{-4}	1.41×10^{-3}	−0.42	0.68
Distance from villages	4.81×10^{-4}	2.37×10^{-4}	2.03	**0.043***
Proportion of forest	-7.47×10^{-2}	2.44×10^{-2}	−3.06	**0.0022****
Proportion of cropland	-1.06×10^{-2}	8.25×10^{-3}	−1.29	0.20

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Discussion

Japanese macaques living on Yakushima Island were more likely to be detected in plantation land use areas rather than forest areas. These results indicate that macaques tend to use plantation areas rather than forested areas. However, it should be pointed out that little forested area was covered due to the time constraints and immediate goal of our study, which was to census logging roads and trails in relatively low-altitude regions nearby croplands and villages. In addition to this, some of the roads censused in our study were in poor condition (e.g. not paved well, covered with fallen trees or stones) and thus it may have been more difficult to detect feces compared to on well paved roads.

In our study, elevation did not have significant effect on the distribution of macaques, contrary to previous studies (Yoshihiro et al., 1999; Yakushima Report 2017). Our censusing efforts were not heavily focused on highland areas but rather lowland areas, so this result may be influenced by a sampling bias. In fact, censuses made in the previous year (2017) were more heavily focused at higher altitude regions. In order to conclusively assess the influence of land use and elevation on the distribution of macaques, we need more data obtained at higher altitude regions.

Macaques were more likely to be detected far away from villages, which may suggest that human activity influences the distribution of individuals on the island. Also, macaques were not

likely to be detected around cropland areas, although crop raiding by macaques is still continued (Yamagiwa, 2008). Macaques on Yakushima Island are sometimes captured or hunted as a method of population control (Yamagiwa, 2008) and the long history of such activities may in part explain why individuals might avoid village areas.

Despite minimal effort, this study managed to shed light on the basic understanding of macaque distribution in Yakushima Island. We propose a long term study of robust design incorporating equal sampling efforts covering different localities, land-use areas and ranges of elevation as the ultimate way of exploring the influence of any bio-physical features towards the distribution of Yakushima macaques.

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