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Short communication

Distribution and habitat selection of species of the genus Tadarida Rafinesque, 1814 (Chiroptera: Molossidae) in the Amami-Oshima Island, Japan

Yushin Asari*

Laboratory of Wildlife Ecology, Obihiro University of Agriculture and Veterinary Medicine, 2-11 Inada, Obihiro, Hokkaido, 080-8555, Japan

*Email: asari@obihiro.ac.jp

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Abstract

Human intrusions and disturbance on Amami-Oshima Island would impact the habitat and behavior of bats. Understanding bat fauna, distribution, and ecology in Amami-Oshima Island is helpful for their conservation. Acoustic surveys were conducted throughout Amami-Oshima Island (ca. 700 km^2) from May 2018 to February 2020. Most locations with positive echolocation results were identified in the southern and western regions. Regional differences between positive and negative detections might reflect habitat quality. A consequence of the higher land use in open areas showed that *Tadarida* sp. flies and forages in such coastal regions and upland fields with few obstacles. Mosaics of forests and open areas should be maintained in the southern and western regions, and the forest quality of the northern part must be improved to provide food resources and open space for flying and foraging bats.

Keywords: Acoustic survey, coastal area, open area, *Tadarida latouchei*, upland field

Introduction

Human activities and land developments put severe pressures on natural environments and wildlife (Venter et al., 2016; Allan et al., 2019). When human disturbances are inflicted upon wildlife, their behavior and habitats change (Sauvajot, 1998; Asari & Yanagawa, 2019). Besides, visitor pressure, such as tourists in natural areas, creates negative impacts on the environment and wildlife (Lynn & Brown, 2003; Taylor & Knight, 2003; Nepal & Nepal, 2004; Steven et al., 2011). The Japanese government aims to list the Amami Islands National Park as a World Natural Heritage site.

Consequently, the number of visitors would undoubtedly increase rapidly (Buckley, 2004, Yang et al., 2010) and negatively affect the natural environment and wildlife.

Insectivorous and frugivorous bats contribute to the biodiversity and ecosystem from pest control and seed dispersal (Russo et al., 2018; Vantoor et al., 2019). However, bats are affected by environmental degradation problems that accompany human developments (e.g., wind power: Foley et al., 2011; roads: Bunkley et al., 2015; artificial light: Stone et al., 2015). Their habitats are also disturbed by tourism (Cardiff et al., 2012; Ivanova, 2017). Therefore, future land work and disturbance on the Amami-Oshima Island would further adversely impact bats' habitats and behaviors.

Understanding bat fauna, distribution, and their ecology is essential to bat conservation on the Amami-Oshima Island. However, bat records there are limited to a few reports (Yoshiyuki et al., 1989; Maeda et al., 2002; Asari & Kimoto, 2018). Asari and Kimoto (2018) noted eight bat species inhabited Amami-Oshima Island, but their distribution and habitat preferences are not well understood. Of these bat species, the confirmed occurrence of La Touche's Free-tailed Bat *Tadarida latouchei* (Thomas, 1920) is based on only one specimen collected at Setouchi Town, south-western of the Amami-Oshima Island in 1985 (Yoshiyuki et al., 1989). The species' current distribution and ecological requirements are unknown; therefore, it was listed as Data Deficient (DD) by the International Union for Conservation of Nature (IUCN) Red List (Francis & Maeda, 2008). However, *T. insignis* (Blyth, 1861) also distributed in western Japan. Therefore, it could not distinguish between the two species by flying shape. Funakoshi et al. (2010) suggest that *T. latouchei* uses echolocation of approximately 20 kHz frequency in the Amami-Oshima Island. In-flight, *T. latouchei* reaches a high altitude, which made it's capturing rather tricky; therefore, echolocation data will help understand this species' distribution and ecology.

This research aims to assess the distribution and habitats used by *Tadarida latouchei* in the Amami-Oshima Island. The results will help to plan conservation area and conservational land use.

Material and methods

The Amami-Oshima Island is located about 370 km southwest of Japan (Kyusyu mainland). This island's topography is a mixture of steep mountains and flat fields; the mountain area consists of evergreen broadleaved forests and conifer forests, while the low land of the north region is the field of sugar cane. Residential areas are dispersed on the island.

Acoustic surveys were conducted throughout the Amami-Oshima Island from May 2018 to February 2020. I drove on most roads on the island at 20–30 km/h to detect bat echolocation, according to Sato et al. (2013) and Schimpp et al. (2018). The location, date, and time were recorded when an approximate of 20-kHz frequency was detected by a bat detector (Anabat Walkabout; Titley Scientific, Queensland, Australia, 5 to 200 range of kHz capability). Echolocation recorded in this island had a peak frequency of 15.74 ± 0.64 kHz (mean ± *SD*), the maximum frequency of 23.74 ± 1.41 kHz, and minimum frequency of 14.75 ± 0.54 kHz with a pulse duration of 11.12 ± 1.66 ms (spectrogram was showed in Fig. 1). These were considered to be positive sites for *T. latouchei* occurrence. I also generated random locations similar to the number of 20-kHz areas using QGIS (QGIS Development Team, 2019). Vegetation at the 20-kHz locations and random locations was identified based on a national vegetation map. At the 20-kHz locations and random locations, 12 and nine vegetation types were classified, respectively. Their places were reclassified into three vegetation types (broadleaved forest, conifer forest, and open area) due to the small

sampling size. Open spaces included upland fields, open water, and city area. To reveal any habitat characteristics of *T. latouchei*, the vegetation of the 20 kHz locations and random locations which made using QGIS geoprocessing tool were compared by a chi-squared test by using R 3.4.2.

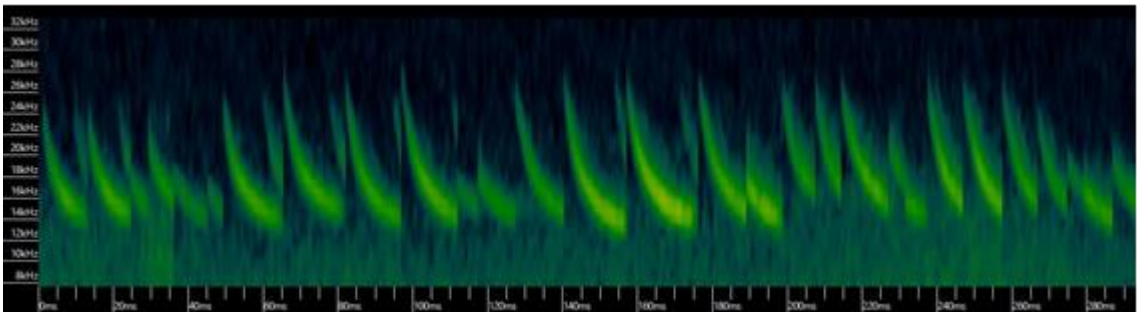

Figure 1. Spectrogram of bat echolocation recorded in Amami-Oshima Island

Results and discussion

Twenty-four locations with 20 kHz recordings were collected in the Amami-Oshima Island. Twenty-one locations of these were recorded in the southern region and western region (Fig. 2). Most of the locations were also near the sea. On the other hand, most of the random locations were evergreen broad-leaved forest.

The habitats used by *T. latouchei* differed significantly from random sites ($\chi^2 = 7.15$, $P < 0.05$). The use of the broadleaved forest by *T. latouchei* was considerably lower than that of random locations ($P < 0.05$). In contrast, open areas used by *T. latouchei* were substantially more significant than that of random locations ($P < 0.01$) (Table 1).

Most trees had been cut throughout the Amami-Oshima Island for commercial purposes after World War II; however, young and mature forests' mosaics are still abundant in the central and southern parts of the island (Sugimura et al., 2003). Therefore, few bat detections in the northern region and most positive locations in the south and western areas of this study might reflect a difference due to habitat quality.

Previous studies on habitat preferences of European Free-tailed Bat *Tadarida teniotis* (Rafinesque, 1814) showed either positive selection by bats for specific forest types (Marques et al., 2004) or no significant differences in habitat preferences (Russo & Jones, 2003). Marques et al. (2004) suggested that habitat selection by *T. teniotis* for specific environments might be caused by a large number of food resources in urban areas and forest fires. Rhodes & Cattreall (2008) also considered that open woodlands and clearing of dense forests might benefit the way of aerial insect supply to White-striped Free-tailed Bat *Tadarida australis* (Gray, 1839) in coastal areas. It is known that faster flight species Silver-haired Bat *Lasionycteris noctivagans* (Le Conte, 1831) selectively used thinned forests (Patriquin & Barclay, 2003). The observation of the higher use of the open areas shows that *T. latouchei* flies and forages in such coastal areas and upland fields with few obstacles because the genus *Tadarida* is believed to fly at high speeds and to be lower maneuverability when considered other small-sized bats (e.g., Maniakas & Youlatos, 2012). Another result is that the use of the broadleaved forests is lower. I predicted that bats would select broadleaved forests; as such, locations generally provide food resources (e.g., insects). However, in contrary to my expectation, bats had negatively selected broadleaved woods. Krusic et al. (1996) suggested that a mixture of mature broadleaved forest and regenerating stand with trails and open water bodies was necessary

for small bats' habitat requirements. Negative use of the broadleaved forest of *T. latouchei* might be a reason that a mixture of multiple forest ages is lack due to forest clear-cutting after World War II in the Amami-Oshima Island.

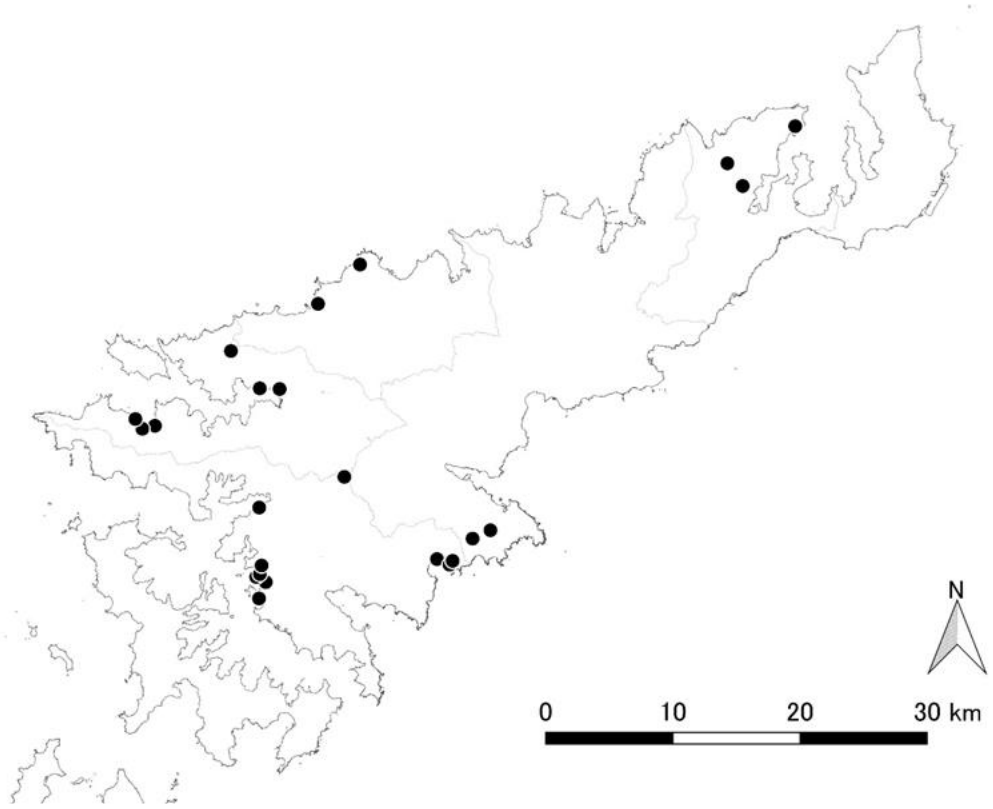

Figure 2. Locations confirmed 20 kHz echolocation.Closed circles show locations of 20 kHz echolocation as *Tadarida latouchei* (presumptive species)

Table 1. Residual analysis of three environmental types in locations.

Environment	20 kHz locations	Random locations
Broad leaved forest	-	+
Conifer forest		
Open area	++	--

Four categories shows significance level and each relationship; --: lower at 0.01 (*P* value), ++: higher at 0.01, -: lower at 0.05, +: higher at 0.05.

Land modification has impacted such as reducing roosting and food resources for bats. Forest clear-cutting driven by land development has already affected wildlife diversity in the Amami-Oshima Island (Sugimura et al., 2014). Therefore, mosaics of forests and open areas should be maintained in the southern and western regions. The northern region's forest quality must be improved to supply food resources and free space for flying and foraging for bats. Suitable roost habitats in the south-western region might be more than in the northern part for *T. latouchei* that roost is considered crevice on cliff (Funakoshi et al., 2019) because the terrain of the south-western coast is steep, while the northern region is relatively flat.

This investigation is the first study on the analysis between the distribution and habitat selection for the little-known *Tadarida latouchei*, contributing to its conservation. It was considered that *T. latouchei* would restricted in a specific area in the Amami-Oshima Island, Japan. This species also selected open areas for flying and foraging. Therefore mosaics of forests and open areas should be maintained in the southern and western regions. Due to few detection localities, the northern region's forest quality must be improved to provide food resources and open space for flying and foraging bats.

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