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Original research article

Q9 Structure and Composition of Reptile Communities in Human Modified Landscape in Gianyar Regency, Bali

Q8 Ida Ayu Ari Janiawati,[1] Mirza Dikari Kusrini,[2]* Ani Mardiastuti[2]

Q1 [1] *Conservation of Tropical Biodiversity Program, Faculty of Forestry, Bogor Agricultural University, Bogor, Indonesia.*

[2] *Department of Forest Resources Conservation and Ecotourism, Faculty of Forestry, Bogor Agricultural University, Bogor, Indonesia.*

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ABSTRACT

As one of the centres of tourism in Bali, Gianyar Regency has undergone a rapid development rate which could threaten wildlife, including reptile community. This research was carried out in July to October 2014 to (1) analyse the reptile community on various gradients of human modified landscape, (2) determine the relationship between environmental character and reptiles, and (3) determine body size trend of generalist species along landscape gradient. Standard visual encountered surveys were used to observe reptile community in four human modified landscape (settlements, rice fields, farmland/cropland, and monoculture stands). We found 21 species of reptiles ($n = 602$ individuals) and the Shannon–Wiener index for diversity was 1.78. Reptile abundance tends to decline in increasing level of modification. Water sources and vegetation cover were positively correlated to reptile community, while disturbance factors (i.e. decrease in area size and shorter distance to settlements) give negative impact to reptile community. There was no correlation between body size of generalist species of reptile (*Gekko gecko*) and level of landscape modification.

1. Introduction

Q2Q3 The existence of human modified landscape is as old as the human existence in the earth. Although the number of wildlife in this landscape might not be as diverse as natural area, human modified landscape plays an important role in the existence of wildlife. Indeed, for some species living in human modified landscape is better than living in the natural area (Liu & Taylor 2004) and they will thrive in this area (Trimble & van Aarde 2004). However, human modified landscape varied according to the degree of human disturbance, for instance city landscapes are more disturbed than farms and traditional villages.

Some areas in Indonesia have changed into human modified landscape such as monoculture stands, farmland/cropland, rice fields, and settlements. In Gianyar Regency, Bali Province, human modified landscapes are mostly caused by high activity in tourism sectors (BPS 2012). Forest and rice fields slowly become scarce and changed into tourist accommodations, restaurants and other related tourism attractions. However, no special attention was given to the impact of that change for wildlife conservation, especially reptiles.

Each type of human modified landscapes has different environment character (habitat and disturbance); therefore, the structure and composition of the reptile community in each formation will be different. Reptile communities that inhabit specific habitat will give different responses to landscape change. For example, conversion of natural forests to plantations will decrease reptile population (Kanowski *et al.* 2006). Research by Andrews *et al.* (2008) showed that the existence of highway may lead to a decrease of abundance and richness of reptile. Highway/road access is one of many consequences of landscape change caused by the existence of human modified landscapes.

In the last decade, declining reptile population has been reported due to habitat degradation, habitat change, and habitat loss (Hokit & Branch 2003; Todd *et al.* 2010). Most reptiles have the highest position in food tropics (Todd *et al.* 2010), thus it has important roles in the ecosystems as predators. Like other predators, the reptile will decrease its body size along with higher habitat disturbance (Gul *et al.* 2014). This research aimed to (1) analyse reptile community in a gradient of modified landscape, (2) analyse the correlation of habitat characters and reptile communities on modified landscape, and (3) analyse body size trend of generalist species in modified landscapes.

* Corresponding author.
E-mail address: kusrini.mirza@gmail.com (M.D. Kusrini).
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2. Methods

The study area was located in five of the five sub-districts of Gianyar: Gianyar, Blahbatuh, Sukawati, Ubud and Tampaksiring. Locations were selected based on elevation, mostly lowlands area (0–800 m above sea level; Figure 1). We selected four types of land use in modified landscape based on level of disturbance. The land use system consisted of monoculture tree stands of *Paraserianthes falcataria* cropland/farmland dominated by annual or semi-annual crops, rice fields with continuous watering *subak* system and traditional Balinese settlements and their gardens.

Samplings were carried out during dry season from July to October 2014. Ten observation points for each land use were selected using stratified random sampling. Surveys were carried out in the morning (6:00 – 8:00 AM) and evening (7:00 – 9:00 PM) for 3 consecutive days for each point. Reptiles were observed using the standard Visual Encountered Surveys (VES) method with 2 hours' time constrained (Doan 2003) by three observers. For every captured reptiles, we recorded coordinates, date and duration of survey, activity, substrates, species name and other supporting information. Identification of reptile was carried out using Das (2010) and McKay (2006). Every individual was measured to obtain data on the body length from snout to the cloaca (snout vent length [SVL]) and the overall length (total length [TL]) using calliper (0.05 mm accuracy), and then body mass using digital scale body weight (0.1 g accuracy) and 10 N spring balance. No specimens were taken, all individuals were released after identification and measured in the same area where they were caught.

Encounter frequency was recorded as individuals per time unit. The encounter frequencies were arbitrarily categorized into frequent (0.04–1.17 individual/min), common (0.02–0.04 individual/min), and rare (0–0.01 individual/min). All individuals were captured (except for the monitor lizard which accidentally escaped) and identified to the species level using Das (2010) and McKay (2006).

Environment characters in term of vegetation cover, presence of water, and degree of disturbance were observed. Canopy closure and undergrowth covers (including woody shrubs, bushes and grasses) were measured for vegetation cover using line intercept techniques (Whitman & Siggeirsson 1954). In each land use system, we selected a 20 × 20 m plot and made 10 transects of 2 m apart. Distance of each individual reptile found to the nearest water source was also recorded. The degree of disturbance was measured as the possible nuisance from human activities surrounding the amphibian habitat. It was measured by the distance of each observation point to the nearest settlement or roads using a geographic information system–based map. All distance coordinates were taken using Garmin Etrex 30. Pre-survey indicated that *Gekko gecko* was abundant and widely distributed. This species was selected for further study on trend of body weight along modified landscape gradient. The SVL and TL of *G. gecko* were measured using a calliper to the nearest 0.05 mm, and then weighed using digital scale to the nearest 0.1 g. All captured individuals were released on site after measurements.

Shannon-Wiener diversity indices (Heip & Engels 1974) were calculated for each type of land use. Differences of species richness among the modified landscapes were examined using Kruskal-Wallis test (Colomba & Liang 2011). The reptile community similarities for each land use type were assessed using single linkage method of Euclidean Distance (Bingham *et al.* 2010) and the dendrogram was drawn using MINITAB 16. To explain the correlation of each environmental character measured to reptile community parameters (abundance, species richness, and species diversity), we used Spearman rank correlation coefficient with an accuracy level of 95% ($p \leq 0.05$) and 99% ($p \leq 0.01$). We conducted similar analysis to see the correlation between disturbance factors to reptile communities.

To assess body condition of *G. gecko*, we used a body mass index (i.e. ratio of the body weight to body length). We used the result to determine the correlation of landscape modification level to body condition of generalist species using Spearman rank correlation coefficient with an accuracy level of 95% and 99%. All statistical tests were analysed by SPSS 16.

3. Results

3.1. Reptile communities in different land use of modified landscapes

We found 23 species of reptiles ($n = 602$ individuals) in four different land uses, consisted of three families of snakes (Colubridae, Natricidae, Phytonidae) and four families of lizards and skink (Agamidae, Gekkonidae, Scincidae, and Varanidae). Lizards were exceedingly abundant and diverse (561 individuals; 13 species) compared to snakes (41 individuals; 10 species) (Table 1).

The highest number of snakes and lizards combination was found in monoculture stands ($n = 259$), followed by farmland/cropland ($n = 173$), rice fields ($n = 119$) and settlements ($n = 51$). In general, the individual abundance and species richness tend to decrease along the higher landscape modification. The trend, however, is different for diversity indices. The highest to the lowest indices were settlements (H' = 1.76), monoculture stands (H' = 1.72), cropland/farmland (H' = 1.51), and rice fields (H' = 0.77). Statistical tests revealed that there were significant differences in abundance ($p < 0.05$; df = 3), and species richness ($p < 0.05$; df = 3) among human modified landscapes. Abundance (mean rank = 34.15) and species richness (mean rank = 31.65) of monoculture stands differed from the other land use types, although settlements showed a slightly higher H' value.

The analysis of the community composition and dendrogram based on abundance and species presence (Figure 2) showed that there were two distinct reptile communities (similarity only about 50%) in the research area: reptiles in settlement areas and reptiles in other three land uses. In the three land uses (monoculture stands, cropland/farmland and rice fields), community similarities were very high (>95%).

3.2. Environmental characters and reptile communities

Habitat characters for each land use types were significantly different among all land use (canopy closure: $p < 0.05$, df = 3; undergrowth cover $p < 0.05$, df = 3; water presence: $p < 0.05$, df = 3). As predicted, the increase of canopy closure percentage significantly increased abundance ($r_s = 0.636$; $p < 0.01$), species richness ($r_s = 0.337$; $p < 0.05$), and species diversity ($r_s = 0.774$; $p < 0.01$). Meanwhile, increase of undergrowth cover could only increase abundance ($r_s = 0.359$; $p < 0.05$) and species richness ($r_s = 0.686$; $p < 0.01$), but not species diversity. As for the water presence, increasing distance from water source significantly reduced the species richness ($r_s = -0.344$; $p < 0.05$).

Distance from the roads as a disturbance predictor did not have significant correlation with the reptile community. Area size had significant and positive correlation to abundance ($r_s = 0.617$; $p < 0.01$), species richness ($r_s = 0.759$; $p < 0.01$), and species diversity ($r_s = 0.367$; $p < 0.01$). Similarly, abundance ($r_s = 0.540$; $p < 0.01$), species richness ($r_s = 0.683$; $p < 0.01$), and species diversity ($r_s = 0.472$; $p < 0.01$) would increase with distance from settlements.

3.3. Body size of *G. gecko* along landscape gradients

G. gecko was found in all land use types ($n = 56$; average 0.03–0.24 individual/min; see Table 2) and was considered as a

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