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Diversity of Amphibians and Reptiles in Various Anthropogenic Disturbance Habitats in Nantu Forest, Sulawesi, Indonesia

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Abstract

The Nantu Forest in Gorontalo Province, Sulawesi, Indonesia holds one of the few remaining pristine habitats in the island. The reserve is surrounded by human habituation which provide opportunity to study the impact of forest lost on biodversity. In addition, data on Nantu mostly focused on big mammals, as there is no previous herpetofauna survey at the area. Sampling of amphibian and reptile was conducted in June 2013 and in May–June 2014 using Visual Encounter Survey method, glue traps and transect sampling in seven different sites at the eastern part of Nantu. We categorized four habitat types based on human disturbances: high disturbed habitat (*HDH*)*, moderate disturbed habitat* (*MDH*)*, low disturbed habitat* (*LDH*) *and pristine habitat* (*PH*)*. A total of 680 individual amphibians* (*4 families; 17 species*) *and 119 individual reptiles* (*9 families; 29 species*) *were recorded. Species richness and species composition for amphibians and reptiles differs according to the level of human disturbances. Low level disturbances habitat demonstrated the highest diversity of amphibians and reptiles, whereas as expected, high distubed habitat showed the lowest diversity. Anthropogenic pressures in forest will decrease species richness of amphibian and reptiles. Although most amphibian and reptiles will be able to persist in low disturbances habitat, forest-dependent species will be lost when pristine forests are disturbed.*

Keywords: anthropogenic disturbances, biodiversity, herpetofauna, Nantu Wildlife Sanctuary, Sulawesi

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Introduction

Tropical forest has long been considered as home for various animals, including endemics. The complex structures of the vegetation provide an important habitat for protection, nesting and foraging for many species, i.e. invertebrates, birds, mammals, and other small vertebrates such as amphibians and reptiles (Williams et al., 2002; DeWalt et al., 2003; Lassau et al., 2005; Bouvet et al., 2016; Bateman & Merritt, 2020). Amphibian and reptiles, known collectively as herpetofauna, provides an important ecosystem service not only as primary, mid level and top consumers but also for nutrient cycling, biological control, seed dispersal, protein sources (food source), raw materials and medicinal and rituals (Cortes et al., 2014; Valencia-Aguilar et al., 2013; Hocking & Babbit, 2014; de Miranda, 2017). Habitat loss, particularly through deforestation and degradation (anthropogenic pressure), is considered the main factors for global decline in population of amphibians (Stuart et al., 2005) and reptiles (Böhm et al., 2013). Indonesia has the highest loss of forest in the tropics (Margono et al., 2014), mostly by anthropogenic pressures i.e expansions of oil palm plantations, conversions to grassland/shrublands, expansions of small-scale agriculture and small-scale mixed plantations (Austin et al., 2019). It has been postulated that protected areas area has low deforestation rate and therefore able to effectively conserve biodiversity (Chape et al., 2005; Gaveau et al., 2012; Shah & Baylis, 2015). However, several studies i.e., in Kalimantan showed that protected forests have become increasingly isolated and deforested (Curran et al., 2004; Susanto et al., 2018). Although the areas are legally protected, encroachments are rife in main islands of Indonesia e.g. in Sumatera (Gaveau et al., 2007), Kalimantan (Currant et al., 2004), and Sulawesi (Supriatna et al., 2020). Type of disturbances are also varying, from low level of disturbance (e.g., exploitation of natural resources) to high level of disturbance (e.g., agricultural practices, illegal exctraction of mineral from the soil). Anthropogenic disturbance altering the pristine habitat in Indonesia is undoubtedly affect the distribution and population of amphibian and reptile (Iskandar & Erdelen, 2006).

Despite known as biodiversity hotspot, Southeast Asia (including Indonesia) is lacking information on biodiversity, distribution and biology of amphibian and reptile compared to the other parts of the world (Iskandar & Erdelen, 2006; Rowley et al., 2009; Koch, 2011). Undoubtedly many more species of amphibian and reptile are awaiting to be discovered and to be assessed. This hold true because in the tropical regions cryptic species is very common, and thus the

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number of species diversity is underestimated (see Bain et al., 2003; Stuart et al., 2006; Che et al., 2009). Increasing rate of land conversion in Southeast Asia, especially Indonesia (Sodhi et al. 2010), has urgently raise concern on the the need for basic information of biodiversity. Sulawesi Island hold the highest endemic species in Indonesia (Whitten et al., 1987). Although research in this island is limited, various publications on Sulawesi amphibian and reptiles has reported many new species to science (Brown et al., 2000; Howard et al., 2007; Kuch et al., 2007; Hayden et al., 2008; Iskandar et al., 2011, 2014; Howard & Gillespie, 2017), several of which are needed to be described (Koch, 2011).

Most of the study on the impact of forest loss in Indonesia to wildlife populations refers to big vertebrates i.e. orang utan, tiger, javan warty pig and birds (see Robertson & Schaik, 2001; Waltert et al., 2005; Semiadi & Meijaard, 2006; Prabowo et al., 2016; Smith et al., 2018). Sulawesi, part of the Wallacean, were noted for its mixture of western and eastern Indo-Australian Archipelago biotic segments, and its endemism. Understanding the impact of forest loss should also highlight the biodiversity of other un-charismatic species for effective conservation management (Muñoz, 2007) i.e. amphibians and reptiles. The Nantu Wildlife Reserve (31.215 ha) in Gorontalo Province is one of the remaining lowland natural areas in Sulawesi, which are the habitat for several endemics mammals such as *babirusa* (*Babyrousa babyrusa*), sulawesi's boar (*Sus celebensis*), anoa (*Bubalus* spp.), sulawesi's black macaque (*Macaca heckii*) and tarsier (*Tarsius spectrum*). In fact, most of the researches in Nantu were focused on mammals (Clayton, 1996; Clayton et al., 1997 Clayton & Macdonald, 1999; Clayton & Milner-Gulland, 1999; Clayton et al., 2000). Other than mammals, there were only a report on diversity of birds (Arini et al., 2011) and one report highlighting finding of a species of bird (Gulson-Castillo et al., 2018), but none on amphibian and reptiles.

Nantu Forest and the surrounding areas provide an opportunity for studying impact of forest habitat conversion due to agricultural activity for amphibian and reptile communities. In this paper we provide the first herpetological species list of Nantu Forest and analyses the amphibian and reptile community in different type of anthropogenic disturbances.

Methods

Study areas This study was conducted in the eastern part of Nantu Wildlife Reserve, Gorontalo Province, Sulawesi, Indonesia (N01°03'00"–N01°34'00"; E125°1'00"–125°15'00"), which is located within Nantu Forest, and adjacent villages outside the reserve (Figure 1). We adopted level of anthropogenic disturbances based on Moy et al. (2016), with distance to the nearest human habitation and the availability of road access as the main consideration. Our survey locations (N = 7) were categorized into four habitat types: (1) high disturbed habitat (HDH): antropogenically disturbed area with good quality road access, e.g rice paddy fields and the surroundingvillages; (2) moderate disturbed habitat (MDH): sites within 150 m away from anthropogenically disturbed area with moderate quality road access, e.g., mixed coconut-corn plantations; (3) low disturbed habitat (LDH): sites within 300 m away from anthropogenically disturbed area with only walking path

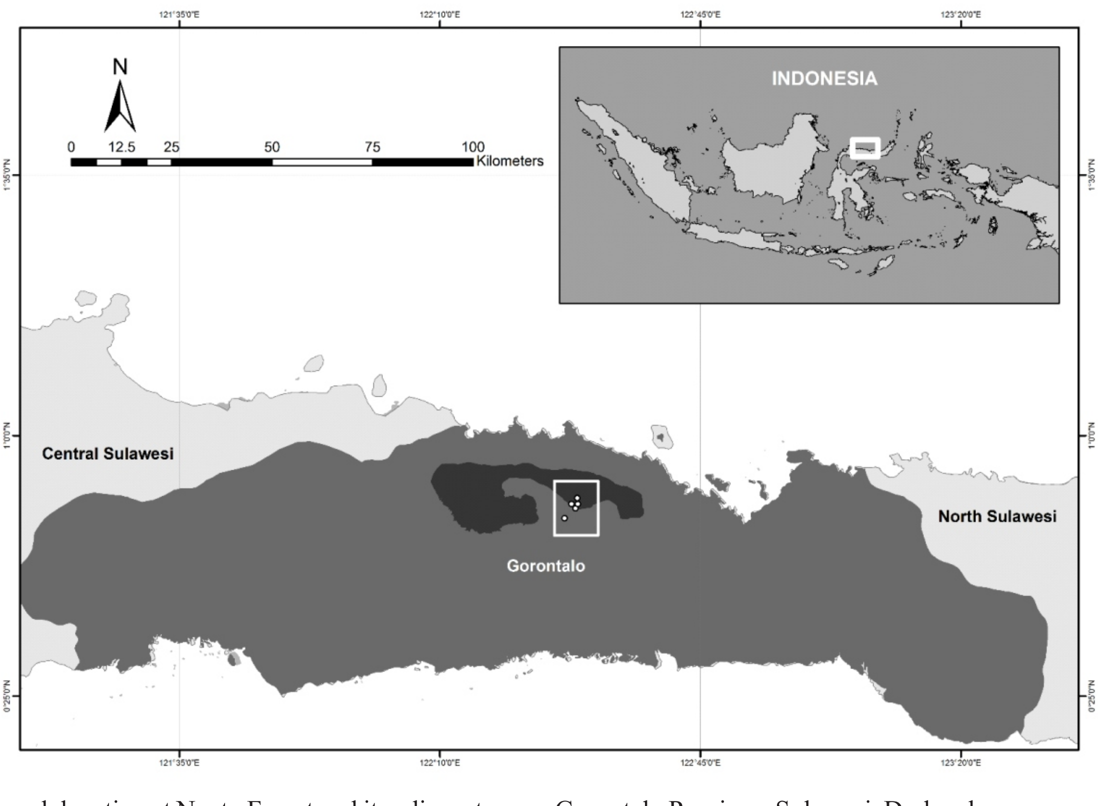

Figure 1 Research location at Nantu Forest and its adjacent areas, Gorontalo Province, Sulawesi. Dark colors represent the whole area of Nantu Forest. White points in squarebox refers to sampling sites.

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access, e.g., secondary forest near the border of the Nantu Reserve (the main human disturbances in this area is the villagers who are harvesting fallen logs for firewood); and (4) pristine habitat (PH), preserved forest inside wildlife reserve, further than 300 m from an anthropogenically disturbed area with almost no road access. All sites have a minimum distance of 500 m from each other in order to minimize problems with pseudoreplication.

Data collection Samplings in the above mentioned location to collect data on the number and species of amphibians and reptiles were performed two times, as described below:

1) June 2013
We employed Visual Encounter Survey (VES) with time constrained method (Heyer et al., 1994; McDiarmid et al., 2012) for two weeks. This approach was peformed by by 3–4 persons in each locality from 1900–2400. The searched was repeated the next day (two nights per locality) covering all microhabitats both in terrestrial and aquatic habitats (streams). Ten glue traps (30 30 cm square board) were put each morning in each sites to capture and record small reptiles i.e. skinks.
2) May–June 2014
For three weeks, we conducted search in the same locations as first year sampling, focusing only on aquatic habitats. Nocturnal transect sampling were carried out by 3–4 persons from 1900–2400 along the stream using three transect (100 m length) for each sites, with 100 m intervals between transect. Searches were made in all possible areas including under leaf litter, logs, branch piles, stones and tree buttresess along the streams, mostly 12 m from the side of the stream body depending on the thickness of forest.

All individuals we encountered during survey were captured, photographed and identified in the field and returned to the field, except for unidentified specimens or with taxonomic uncertainty which were collected and preserved using 70% alcohol for re-examination in lab to confirm their identities. Identification were conducted using papers and reports on Sulawesi frogs (i.e Brown & Iskandar, 2000; Iskandar et al., 2011a; Iskandar et al., 2014; Kusrini et al., 2015), or reptiles (i.e. Brown et al., 2000, de Lang & Vogel, 2006; Howard & Gillespie, 2007; Howard et al., 2007; Hayden et al., 2008; Linkem et al., 2008; Kuch et al., 2007; Koch, 2008; Iskandar et al., 2011b; Riyanto et al., 2016). All specimens were deposited in Museum Zoologicum Bogoriense (MZB). We follow Frost (2018), de Lang and Vogel (2006), and the reptile database (Uetz & Hosek, 2014) for amphibians, snakes, and reptile's nomenclature, respectively.

Data analysis We pooled data from first year and second year of sampling and generated a table with list of the species, incorporate information on habitat use, relative abundance, and its conservation status following IUCN Red list of Threatened Species (IUCN, 2020). We analyzed diversity of amphibian and reptile communities in different type of anthropogenic disturbances using Shannon diversity indices (H), equitability (evenness; E) (Magurran, 2010) and predicted the number of species in each type of habitat following Chao et al. (2009). Student's *t*-test was used to assess the significance of differences of diversity between level of disturbances. Data analysed were based on results from VES in 2013 and transect sampling in 2014. We omitted glue traps data as it only resulted in low number of species captured which also found during VES and transect sampling. We also ran cluster analyses to construct a dendogram for amphibian and reptile communities using Bray-Curtis similarity Index and single linkage method (Bloom, 1981). All analyses were performed using Paleontological Statistics (PAST) version 3.21 (Hammer, 2018).

Results and Discussion

We recorded 680 individuals of amphibian representing 17 species and 119 individuals of reptile representing 29 species (Table 1 & Table 2). Species accumulation curves for all locations showed that after 15 days, number of amphibian richness increases very slowly with continued sampling effort, whereas at the same time for reptiles there is a higher increase of species number with continued sampling effort (Figure 2). These result is similar with the estimation of species richness based on Chao-1 (Table 3). We recorded two unidentified species of skinks (*Sphenomorphus* sp.) and only assigned identification to genus level pending deeper taxonomic analyses to establish the identity of the species. One species has a significant resemblance to a known species but it is still uncertain, thus a *cf* is put between genus name and species (*Lamprolepis cf smaragdina*). One species of amphibian, found with tadpoles in her stomach was assigned only as genus level during survey (*Limnonectes* sp). All amphibians were recorded during nocturnal survey and 7.56% of reptiles were taken from glue traps which consisted of 5 species: *Emoia caeruleocauda*, *Eutropis rudis*, *Hemiphyllodactylus typus*, *Lipinia quadrivittata*, and *Lygosoma bowringii*. All reptiles taken from glue traps were also recorded during nocturnal survey.

While the majority of amphibians recorded from this study are categorized as least concern (LC), three species are listed as vulnerable (VU: *Chalcorana macrops, Limnonectes heinrichi* and *Rhacophorus monticola*) and one species is not assessed (*Polypedates iskandari*). Interestingly, most species of reptiles recorded in this study (75.6%) fell into none of IUCN categories because they have not been evaluated to date. Two species of reptiles are listed as *Data Deficient* (*Ptyas dipsas* and *Rhabdophis chrysargoides*) and 6 species are listed as LC; 70.6% (12 species) of the total amphibians were endemics and only 20.7% (6 species) of reptiles were endemic. Additionally, the two unidentified species of *Sphenomorphus* could be new to science. Given the high endemism in Sulawesi, it is possible that they only distributed in the island. Suprisingly, the percentage of endemics species and relative abundance of endemic amphibian tends to decrease along disturbance gradient. This pattern is also demonstrated in reptiles, except for the pristine habitat (Table 3).

Individual rarefaction values for amphibian and reptiles showed that the highest number of individual and highest species number was observed in low disturbance habitat. On the other hand, for amphibian the second highest number of

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Table 1 Amphibian species of the Nantu Forest and its adjacent areas, Gorontalo Province. IUCN Red List categories: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient; NE = not evaluated by the IUCN (IUCN 2020); Endemic [Y(yes)/N(no)/?(not known)] = Sulawesi endemic; Habitat category: PH = Pristine habitat; LDH = Low disturbed habitat; MDH = moderate disturbance habitat (mixed coconut-corn plantation); HDH = high disturbed habitat (Rice Field and Village).

Species	IUCN red list category	Endemic	Habitats category
Bufonidae			
Duttaphrynus melanostictus (Schneider, 1799)	LC	N	HDH, MDH, LDH
Ingerophrynus celebensis (Günther, 1859)	LC	Y	MDH, LDH, PH
Dicroglossidae			
Fejervarya cancrivora (Gravenhorst, 1829)	LC	N	HDH, MDH, LDH
Fejervarya limnocharis (Gravenhorst, 1829)	LC	N	MDH, LDH, PH
Limnonectes grunniens (Latreille, 1801)	LC	N	MDH, LDH, PH
Limnonectes heinrichi (Ahl, 1933)	VU	Y	MDH, LDH, PH
Limnonectes larvaepartus Iskandar, Evans & McGuire, 2014	LC	Y	MDH, LDH, PH
Limnonectes modestus (Boulenger, 1882)	LC	N	MDH, LDH, PH
Occidozyga celebensis (Smith, 1927)	LC	Y	MDH, LDH, PH
Occidozyga semipalmata Smith, 1927	LC	Y	MDH, LDH
Ranidae			
Chalcorana macrops (Boulenger, 1897)	VU	Y	MDH, LDH, PH
Chalcorana mocquardii (Werner, 1901)	LC	Y	LDH, PH
Hylarana celebensis (Peters, 1872)	LC	Y	MDH, LDH, PH
Rhacophoridae			
Polypedates iskandari Riyanto, Mumpuni, & Mcguire, 2011	NA	Y	MDH, LDH
Rhacophorus edentulus Mueller, 1894	LC	Y	PH
Rhacophorus georgii Roux, 1904	LC	Y	LDH, PH
Rhacophorus monticola Boulenger, 1896	VU	Y	PH

individual was recorded by moderate disturbance habitat, whilst for reptiles was pristine habitat (Figure 3). In general, species richness and diversity differ between habitats. High modified landscape with high anthropogenic pressure has lowest amphibian and reptile diversity compared to other habitat (Table 3).

There was a significant differences of Shannon diversity indices for amphibian between HDH with LDH ($t_{(7)}$ = -5.31, $p < 0.001$), MDH ($t_{(6)}$ = -5.3, $p < 0.001$) and PH ($t_{(7)}$ = -5.31, $p < 0.001$). However, there was no significant differences of diversity of amphibian between MDH and LDH ($t_{(286)}$ = 0.47, $p = 0.634$), between LDH and PH ($t_{(174)}$ = -0.53, $p = 0.597$), nor PH with MDH ($t_{(240)}$ = -0.07, p = 0.944). Low disturbance habitat had the lowest evenness (0.45) caused by the high abundance of *Limnonectes modestus*. The pattern was similar for reptile, there was a significant differences of Shannon diversity index between HDH with LDH ($t_{(15)}$ = -6.85, $p < 0.001$), MDH ($t_{(13)}$ = -6.99, $p < 0.001$) and PH ($t_{(17)}$ = -5.31, $p < 0.001$). There was no significant differences of diversity of reptile between MDH and LDH ($t_{(78)}$ = -0.21, $p = 0.833$), between LDH and PH ($t_{(74)}$ = 1.69, p = 0.095), nor PH with MDH ($t_{(62)}$ = 1.60, p = 0.114). Evennes values in all habitats was quite high (0.63 in LDH to 0.79 in MDH) because no species dominated in all locations.

For both amphibian and reptile, HDH had the highest differences of species composition with other habitats. Although there were no significant differences between diversity indices in MDH, LDH and PH, the composition between those habitats differs (Figure 4). Low disturbance habitat and medium disturbance habitat had 54% similarities, and together they had 50% similarities with pristine habitat. For reptiles, pristine habitat and moderate disturbance habitat had 32% similarities, and together they only had 23% similarities with low disturbance habitat. Figure 5 shows how composition changes along anthropogenic disturbances.

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Table 2 Reptile species of the Nantu Forest and its adjacent areas, Gorontalo. Red List classifications follow the criteria of IUCN (IUCN 2020): CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient; NE = not evaluated by the IUCN; Endemic [Y/N/?] = species considered an endemic from Sulawesi; Habitat encountered = habitat where we encountered the species; abbreviations used: PH = Pristine habitat; LDH = Low disturbed habitat; MDH = moderate disturbance habitat (mixed coconut-corn plantation); HDH = high disturbed habitat (Rice Field and Village).

Species	IUCN red list category	Endemic	Habitat encountered
Agamid Lizard/Agamidae			
Bronchocela cristatella (Kuhl, 1820)	NE	N	MDH
Geckoes/Gekkonidae			
Cyrtodactylus jellesmae (Boulenger, 1897)	NE	Y	LDH, PH
Gehyra mutilata (Wiegmann, 1834)	NE	N	HDH
Gekko monarchus (Schlegel, 1836)	NE	N	PH
Hemidactylus frenatus Dumeril & Bibron, 1836	LC	N	HDH, MDH
Hemiphyllodactylus typus Bleeker, 1860	LC	N	LDH
Monitor lizards/Varanidae			
Varanus salvator (Laurenti, 1768)	LC	N	LDH
Skinks/Scincidae			
Emoia caeruleocauda (De Vis, 1892)	LC	N	MDH, LDH
Eutropis rudis (Boulenger, 1887)	NE	N	MDH, LDH, PH
Lamprolepis cf smaragdina	NE	N	PH
Lipinia quadrivittata (Peters, 1867)	LC	N	LDH
Lygosoma bowringii (Günther, 1864)	NE	N	LDH, PH
Sphenomorphus variegatus (Peters, 1867)	NE	N	LDH
Sphenomorphus undescribed *sp.1*	NE	Y?	PH
Sphenomorphus undescribed *sp.2*	NE	Y?	PH
Snakes			
Colubridae			
Boiga dendrophila (Boie, 1827)	NE	N	MDH, LDH
Boiga irregularis (Bechstein, 1802)	LC	N	LDH
Chrysopelea paradisi celebensis Mertens 1968	LC	Y	LDH
Dendrelaphis pictus (Gmelin, 1789)	NE	N	MDH, LDH
Lycodon stormi Boettger, 1892	NE	Y	LDH
Psammodynastes pulverulentus (Boie, 1827)	NE	N	MDH, PH
Ptyas dipsas (Schlegel, 1837)	DD	Y	LDH
Rhabdophis callistus (Günther, 1873)	NE	Y	MDH, LDH
Rhabdophis chrysargoides (Günther, 1858)	DD	N	MDH, PH
Cylindrophiidae			
Cylindrophis melanotus Wagler, 1828	NE	Y	MDH
Gerrhopilidae			
Gerrhopilus ater (Schlegel, 1839)	NE	N	MDH
Pythonidae			
Malayopython reticulatus (Schneider, 1801)	LC	N	MDH
Viperidae			
Tropidolaemus subannulatus (Gray, 1842)	LC	N	LDH
Tropidolaemus wagleri (Boie, 1827)	LC	N	MDH, LDH, PH

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Our study corroborated Iskandar and Tjan's (1996), Setiadi et al. (2011), and Koch (2011) hypothesis that Sulawesi is an important habitat for amphibian and reptiles, some with unique natural histories. The unidentified species of Limnonectes were later described as *Limnonectes larvaepartus* (Iskandar et al., 2014). The reproductive biology of this frog is distinct to other species, i. e., female frogs gives birth to tadpole instead of releasing eggs to open water (Iskandar et al., 2014; Kusrini et al., 2015).

Compared to other previous research in Sulawesi, the number of species, especially for reptile is relatively low. Gillespie et al. (2005) reported 12 species of amphibian and 55 species of reptile in Lambusango Wildlife Reserve and its

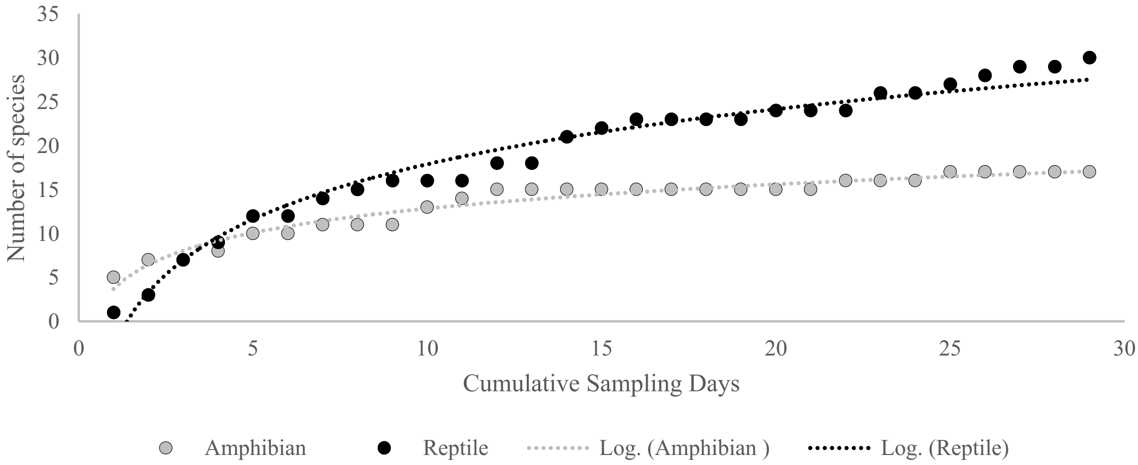

Figure 2 Species-accumulation curves for amphibians and reptiles surveys in Nantu Forest and its adjacent areas, Gorontalo. Cumulative sampling days are the two survey periods (2013 and 2014) combined in sequence.

Table 3 Summary of amphibians and reptiles' community metrics in high disturbed habitat (HDH), medium disturbed habitat (MDH), low disturbed habitat (LDH) and pristine habitat (PH) in Nantu Forest and its adjacent areas. Relative abundance (number of individuals/meter or n/m)* is based on stream transect data from the second year only. Species observed (Sobs) is based on result of survey. Estimate of species (Sest) based on Chao-1.

Measure	High disturbed (HDH)	Moderate disturbed (MDH)	Low disturbed (LDH)	Pristine (PH)
Amphibians				
Relative abundance (n/m)*	0	41	118.7	22.3
Sobs	2	14	15	12
Sest	2	14	16	12
%Sendemic	0	60	66.7	75
%Abundance of endemic species	0	38.8	47.3	66.3
Species diversity (H’)	0.45	1.97	1.92	1.97
Species evennes (E)	0.78	0.51	0.45	0.60
Reptiles				
Relative abundance (n/m)*	0	7.7	8	6
Sobs	2	13	17	11
Sest	2	18	22	16
%Sendemic	0	15.4	29.4	27.3
%Abundance of endemic species	0	9.4	19.6	15.2
Species diversity (H’)	0.38	2.33	2.38	1.98
Species evennes (E)	0.73	0.79	0.63	0.66

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surrounding area (Buton Island, Southeast Sulawesi) whereas Wanger et al. (2011) reported 25 species of amphibian and 54 species of reptile in Lore Lindu National Park. The difference might be caused by the duration of survey. Both Gillespie et al. (2005) and Wanger et al. (2011) conducted their research repeatedly over three years.

There was a clear difference of composition of amphibian and reptiles between different types of land affected by human disturbance (Figure 5 and Figure 6). High disturbance habitat, i.e. rice paddy field has the lowest diversity, with only two species of amphibians (*Duttaphrynus melanostictus* and *Fejervarya cancrivora*) and two species of reptiles (*Gehyra mutilata* and *Hemidactylus frenatus*) present. These species are tolerant to human impact (Iskandar, 1998) and their distribution have been assisted by human (Church, 1960; Iskandar, 1998). In moderate disturbance habitat, i.e. mixed coconut and corn plantations, number of species increase but mostly dominated by species adapted to human dominated landscape such as *Ingerophrynus celebensis, Fejervarya limnocharis* and *Emoia caerulocauda*. Stream surveys in second year yield more species than first year sampling, however, no additional species were found in high disturbance habitat.

The diversity of amphibian and reptile in moderate disturbance, low disturbance and pristine habitat is nearly similar but differ in the composition. Low disturbance habitat and pristine habitat has the highest

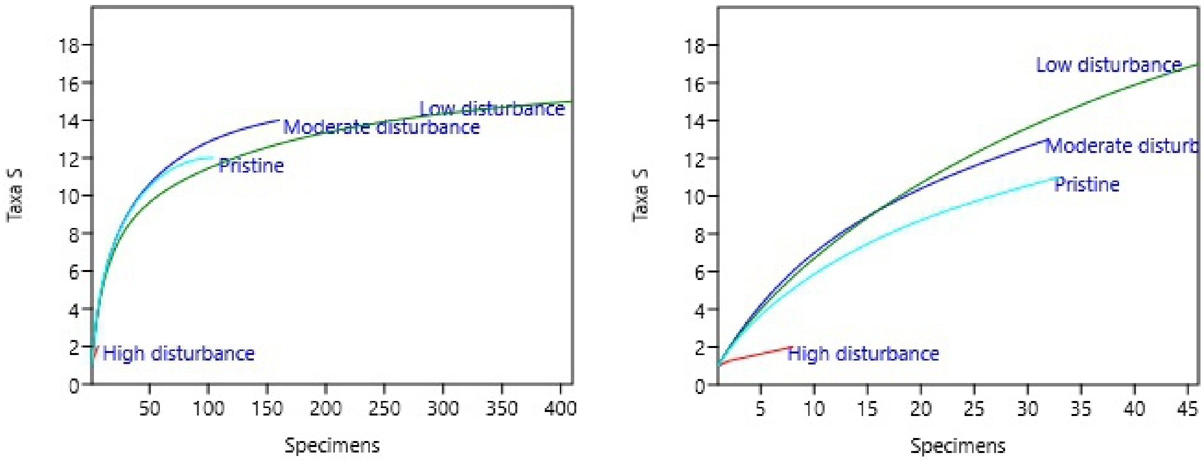

Figure 3 Observed species richness (Taxa S), calculated by sample-based rarefaction curves and scaled to show the number of individuals (specimens) on the x-axis for amphibians (left) and reptiles (right) across habitat disturbance gradient.

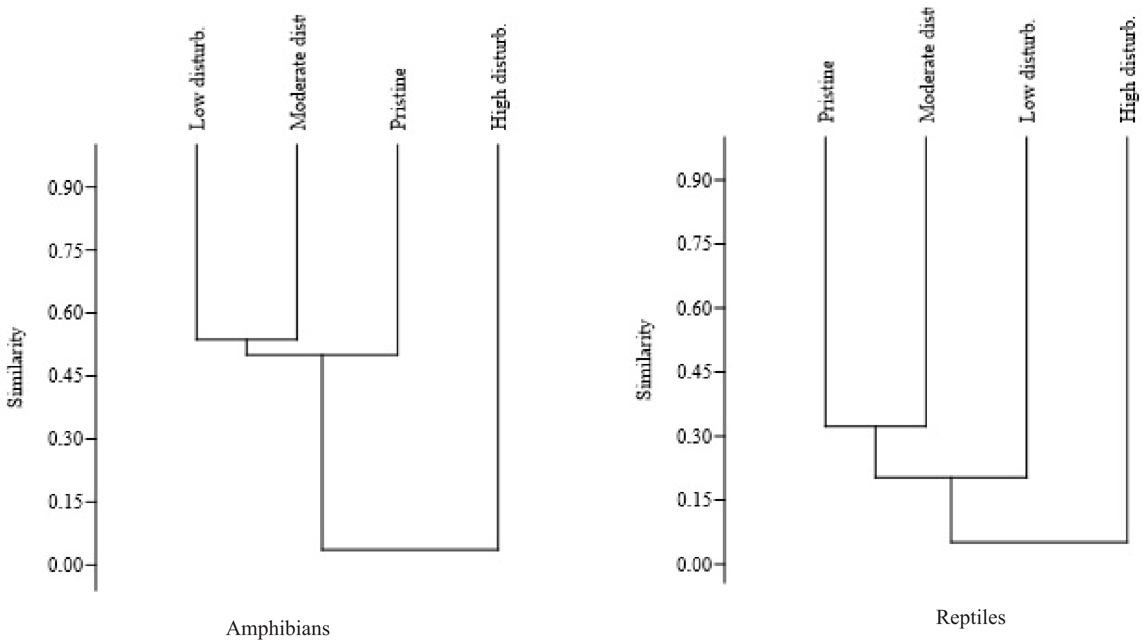

Figure 4 Dendrogram of Bray-Curtis's coefficient of similarity across habitat with different disturbances gradient based on amphibian species composition (left) and reptiles (right).

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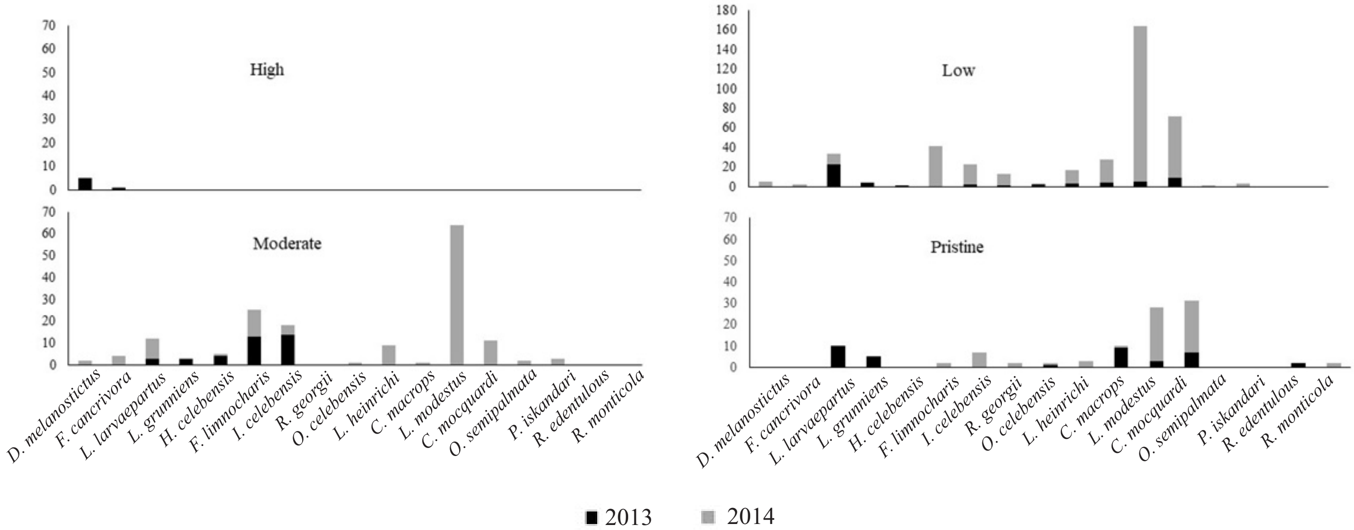

Figure 5 Change of amphibians' composition along anthropogenic disturbances gradient in Nantu Forest and its adjacent areas from high anthropogenic disturbances (top) to pristine habitat (bottom).

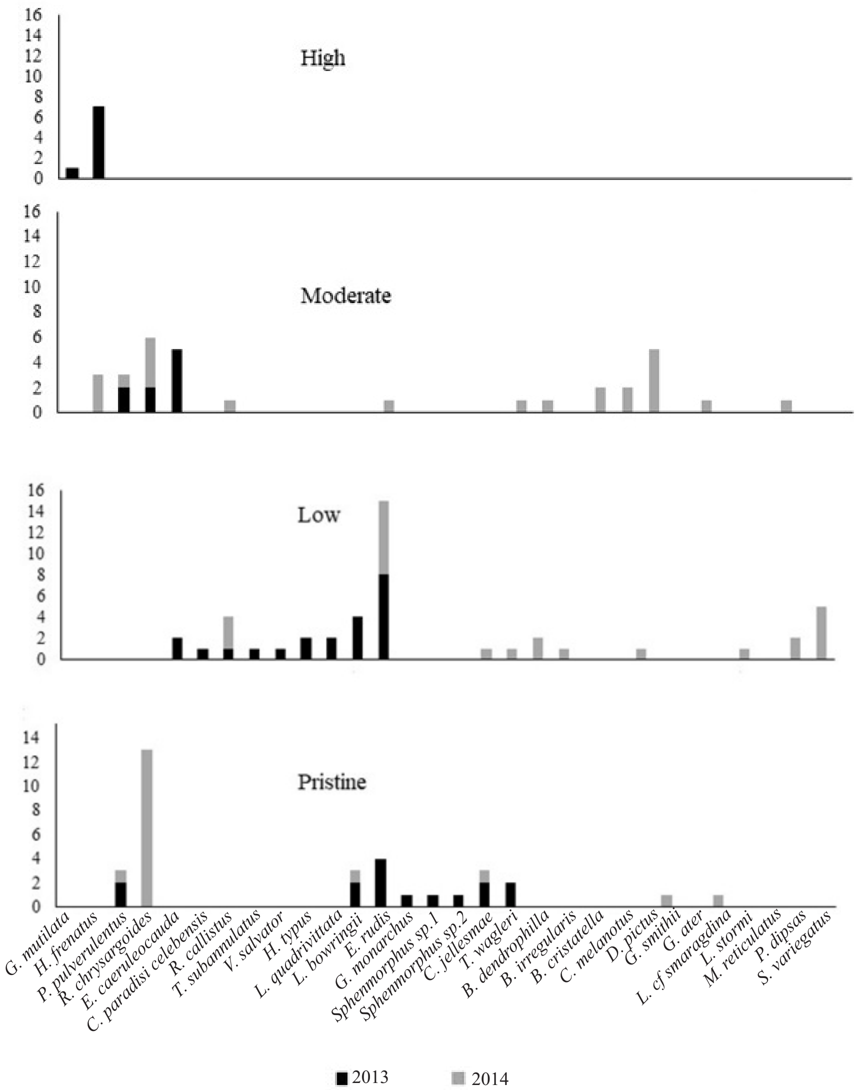

Figure 6 Change of reptiles' composition along anthropogenic disturbances gradient in Nantu Forest and its adjacent areas from high anthropogenic disturbances (top) to pristine habitat (bottom).

relative abundance of amphibians, as well as percentage of endemic species and bundance of endemic species. The trend is nearly similar for reptiles, although pristine areas has lower relative abundance and lower percentage of endemic species compared to the one in low disturbance habitat. Our study cooroborated Wanger et al. (2010) and Gillespie et al. (2015) that amphibian and reptile richness in Sulawesi is greater in minimally disturbed sites and pristine area than high disturbed sites. However, in contrary to Wanger et al. (2010), our finding did not show that species richness of amphibian decrease from pristine forest to open area. The number of species and abundance for amphibian and reptile is highest in sites with low anthrophogenic disturbance, which supported by the intermediate disturbance hypothesis (Huston, 1979). Huston (1994) suggested that maximum diversity occurs at intermediate level of disturbance. On the other hand, both low disturbance habitat in this study and in Buton (Gillespie et al., 2015) are adjacent to pristine forest which might serve as source of colonization. Protection of forest in Nantu is beneficial for herpetofauna richness. Loss of pristine forest will have caused loss of species, which might be endemic and new to science (i.e. *Spenomorphus* sp.)

Conclusion

Anthropogenic pressures in forest will decrease species richness of amphibian and reptiles. Most amphibian and reptile will be able to persist in low disturbances habitat, but forest dependent species, some might be endemics, will be lost when pristine forests are disturbed. Nantu Forest is a hotspot of amphibian and reptile endemic species, therefore monitoring of amphibian and reptiles should be conducted regularly.

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