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Species diversity of skinks (Family: Scincidae) as influenced by land use systems in Southern Leyte, Philippines

Rolibel S Timon, Litlen P Dapar*

Department of Forest Science, Biliran Province State University (BiPSU), Biliran Campus, San Isidro, Biliran, Biliran, Philippines

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Abstract

To determine the species composition, distribution and diversity of skinks in the different land use systems, three 10 m x 20 m sampling plots were randomly laid out equidistant from each other in the agroforestry, exotic tree plantation, native tree plantation, and secondary forest sites in Brgy. Lunas, Maasin City, Southern Leyte. Sampling and collection of specimens were done at different times of the day in each sampling plot. Specimens were identified down to the species level by referring to photo-documentations of published journal articles, thesis manuscript, monograph, and Dr. Rafe Brown. A total of 6 species of skinks in 4 genera with 66 individuals were recorded including *Sphenomorphus acutus* Peters, *S. fasciatus* Gray, *Eutropis multicarinata* Gray, *E. multifasciata* Kuhl, *Brachymeles orientalis* Brown and *Pinoyscincus jagori* Peters. Among the scincid lizards, *E. multifasciata* was the widely distributed and most abundant skink species while *Sphenomorphus fasciatus* was encountered solely in the exotic tree plantation dominated by mahogany [*Swietenia macrophylla* (L.) Jacq.)]. In terms of species diversity, exotic tree plantation and secondary forest had relatively comparable diversity indices (H'=0.4736; H'=0.4662) and species richness (R_2=0.3077; R_2=0.3750) while agroforestry had the lowest diversity index (H'= 0.1446) and species richness (R_2=0.0811). Further, exotic tree plantation, native tree plantation and secondary forest also had comparable evenness indices (E_s=0.7866; E_s=0.7619; E_s=0.7743). Surprisingly, the results showed that exotic tree plantations could also exhibit certain levels of species diversity, particularly on scincid lizards, and should be included in any wildlife conservation programs.

***Corresponding Author:** Litlen P. Dapar ✉ litlenphils_84@yahoo.com

Introduction

Several literatures (e.g. Amos *et al.*, 2019; Laurance, 2004; Lawler *et al.*, 2014; Millennium Ecosystem Assessment, 2005) have discussed the negative impacts of land use and land cover change on ecosystem dynamics and stability, particularly on plant and animal interactions, population dynamics and species persistence. One of the major direct effects of land use and land cover change is habitat fragmentation, which involves the splitting of natural habitats and ecosystems into smaller and more isolated patches (Mullu, 2016) including conversion of native grasslands, forests, and wetlands into croplands, tree plantations, and developed areas to increase production of food, timber, housing, and other commodities (Lawler *et al.*, 2014). Habitat fragmentation and habitat loss is currently regarded as a primary issue in conservation biology and wildlife conservation (Mullu, 2016).

To be able to develop effective conservation management strategies, assessment of population parameters including size, density, and distribution of species across landscapes are of vital significance (Krüger, 2006). Moore *et al.* (2013) further cited that studies on population size and density are important for long-term monitoring, and the distribution of individuals over time and space are useful in targeting key areas of protection.

Hence, this study is a contribution to this scientific endeavor, particularly in the face of global warming and climate change that may have profound effects on the species' ability to survive and reproduce which could in turn influence species' abundance and distribution patterns. Lopez-Alcaide and Macip-Rios (2011) after Dunham (1993) and Grant and Porter (1992) reported that an increase in average temperature may affect the spatial distribution, physiological performance, reproductive biology and behavior of terrestrial ectotherms such as skinks. Specifically, it aimed to identify the species of skinks, determine the distribution, abundance, and occurrence of skink species, and compare the diversity indices of skink species in various land use systems.

Material and methods

Establishment of Sampling Plots

A scientific benchmarking was conducted to select the study sites and establish representative sampling plots at the 5,046 hectares of the YESIDA project area in Brgy. Lunas, Maasin City, Southern Leyte. Three 10 m x 20 m sampling plots were randomly laid out equidistant from each other in the agroforestry, exotic tree plantation, native tree plantation, and secondary forest sites (Fig. 1).

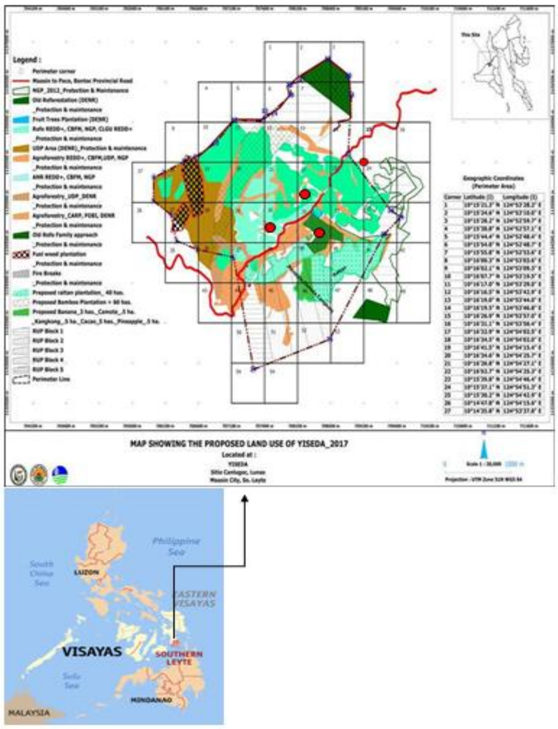

Fig. 1. Map of YESIDA project area in Southern Leyte showing the study sites.

Sampling and Collection of Specimen

Observation and collection of specimens were done at 9:00 A.M., 12:00 Noon, and 3:00 P.M. because reptiles are said to be most active in the morning and early afternoon (0900 h to 1500 h). The forest floor within the sampling plots was systematically and extensively searched for the presence of skinks. Special attention was given to microhabitats including tree trunks, tree crevices, and root tangles, leaf litters, beneath rocks, fallen logs, tree holes, tree buttresses, bark, leaves, ferns, shrubs, moss, and vegetation debris. All skink species encountered in each sampling plot were identified and the numbers of individuals per species were counted. Since skinks are mobile, those individuals that move outside the sampling plots were included (Dapar and Patindol, 2008 after Haribon Foundation, 2001).

Identification of Specimen

All captured specimens were photographed and marked before being released to aid in species identification and verification. The specimens were identified down to the species level by referring to photo-documentations of published journal articles (Sanguila *et al.*, 2016; Brown *et al.*, 2013a), published thesis manuscript (Dapar and Patindol, 2008), field identification guide (Alcala, 1986), monograph (Taylor, 1922a), and Dr. Rafe Brown (personal communication, July 20, 2018) for validation purposes.

Data Processing and Analyses

The data acquired were encoded using Microsoft Excel 2010 and computation of diversity indices were also calculated using said program. Using the data on the number of individuals for each species, the following indices were computed:

1. Species Richness Index (Menhinick's Index)

$(R2) = {}^{S}/\sqrt{n}$

Where:

S = total no. of species observed

N = total no. of individuals observed

2. Species Diversity (Shannon-Wiener Index)

$H' = \sum_{i=l}^{s} Pi \ln P_i$

Where:

H' = Shannon-Wiener Index

S = no. of species

P_i = proportion of individuals of the abundance of the ith species expressed as proportion of total abundance (ni/N)

ln = log base n

3. Evenness Index

$E_s = H'/\log S$

Where:

H' = Shannon Index of Diversity

S = no. of species

Result and discussion

Species Composition

A total of 6 skink species in 4 genera with 66 individuals were recorded in this study (Table 1). The genus *Sphenomorphus* was represented by *Sphenomorphus acutus* Peters (Point-headed Sphenomorphus) and *S. fasciatus* Gray (Banded Spenomorphus). On the one hand, genus *Eutropis* was represented by *Eutropis multicarinata* Gray (Two–striped Mabuya), and *E.multifasciata* Kuhl (Many–lined sun skink). The rest of the genera, *Brachymeles* and *Pinoyscincus* are each represented by a single species, Brachymeles *orientalis* Brown (Elongate short–legged burrowing skink) and *Pinoyscincus jagori* Peters (Jagor's Spenomorphus), respectively. Among the species collected, *Eutropis* and *Sphenomorphus* were the most represented genera with 2 species each while *Brachymeles* and *Pinoyscincus* were the least represented genera with only 1 species each. The genus *Eutropis* had the highest number of individuals encountered (49) while *Pinoyscincus* was the least with only 2 individuals (Table 2).

Table 1. Species of skinks recorded in different land-use systems.

Genera	Scientific Name	Common Name
Eutropis	*E. multicarinata*	Two–striped Mabuya
	E. multifasciata	Many–lined sun skink
Brachymeles	*B. orientalis*	Elongate short–legged burrowing skink
Pinoyscincus	*P. jagori*	Jagor's Sphenomorphus
Sphenomorphus	*S. acutus*	Point–headed Sphenomorphus
	S. fasciatus	Banded Sphenomorphus

Table 2. Number of species and individuals per genera of skinks.

Genera	Number of Species	Number of Individuals
Brachymeles	1	8
Eutropis	2	53
Pinoyscincus	1	2
Sphenomorphus	2	3
Total	6	66

The species composition of skink in Southern Leyte differed from the findings of Dapar and Patindol (2008) in the province of Leyte.

Their study found 7 species of skinks in 5 genera including *Lipinia pulchella* Gray, *Lamprolepis smaragdina* Mertens, *S. jagori* Peters, *S. decipiens* Boulger, *S. cumingi*, Gray, *S. variegatus* Peters, and *Mabuya multicarinata* Gray. *Spenomorphus* was the most represented genus with 4 species and had the highest number of individuals recorded (139) while *Lipinia* was the least with only 4 individuals.

Such variations in species composition between the two provinces could be attributed by the influence of land-use systems that results to habitat fragmentation. Mullu (2016) after Temple (1986) emphasized that habitat fragmentation results in quantitative and qualitative losses of habitat for species which originally depend on that habitat type, and often results in the decline of particular species' abundance and diversity where losses are most noticeable in smallest fragments. Some adverse effects of habitat fragmentation to both wildlife populations and species include increased isolation of populations or species, opportunities for exploitation by humans and edge effect, and changes in habitat plant composition, type and quality of the food base, energy flows and nutrients, availability of cover and microclimates (Parker and Nally, 2002).

Another possible reason for said variations was the behavioral characteristics of skink species towards microhabitat selection. George and Zack (2001) revealed that the presence of a species in a specific habitat type is largely influenced by microhabitat selection wherein certain habitat types are selected because they provide the microhabitat features, thus allowing the species to meet its biological and physiological requirements (Huey, 1991) and having an influence on geographic distribution, abundance, and population dynamics (Munday *et al.*, 1997).

As such, microhabitat features are particularly critical for ectothermic species including reptiles since ectotherms use microhabitat features to regulate their body temperature relative to ambient temperatures (Grover, 1996). The declines of several species of lizard have been linked to a decline in the availability of key habitat features (Howes and Lougheed, 2004).

Distribution, Abundance, and Occurrence of Skink Species in Different Land-use Systems

The distribution, abundance, and occurrence of skink species as influenced by land-use systems is presented in Table 3. As shown in the table, *Eutropis multifasciata* was the widely distributed and the most abundant scincid lizard. It was found in all sampling sites with 49 individuals, which only means that *E. multifasciata* is a generalist species having a wide range of environmental tolerance and occupying different microhabitat types in forested and shrubby habitats even if such habitats are under cultivation and are degraded. Brown *et al.* (2013) after Alcala *et al.* (1980) and Manthey and Grossman (1997) cited *E. multifasciata* is active in open sun at midday, and commonly encountered in the Philippines at lower elevations along edges of agricultural land surrounding disturbed forest patches where it can be observed actively foraging in the open and retreating into nearby shrubs when disturbed.

Table 3. Distribution, abundance, and occurrence of skink species as influenced by land use systems.

Species	Study Site				
	Agroforestry	Exotic Tree Plantation	Native Tree Plantation	Secondary Forest	No. of Individuals
S. acutus	X	1	X	1	2
S. fasciatus	X	1	X	X	1
E. multicarinata	2	X	1	1	4
E. multifasciata	34	4	6	5	49
B. orientalis	X	7	1	X	8
P. jagori	1	X	X	1	2
Total	37	13	8	8	66

Note: X= absent

Brachymeles orientalis was found both in native tree and exotic tree plantations with 8 individuals. Based on the observation of Siler *et al.* (2010), *B. orientalis* is a semi-fossorial slender skink that can be found in residential, disturbed, and secondary-growth forest at low elevations, and is commonly observed in soil and forest floor detritus around tree buttresses and under nearly any form of ground cover in coconut palm plantations near the forest.

Eutropis multicarinata was also encountered in agroforestry, native tree plantation and secondary forest with 4 individuals. This species can be found basking in open sunny patches, particularly in extensively used plantations with a mixture of ample decaying leaf litter and grass (Denzer, 1994), but is extremely difficult to capture, despite being frequently observed (Brown *et al.*, 2012).

Pinoyscincus jagori was recorded in agroforestry and secondary forest with 2 individuals. Sanguila *et al.* (2016) described the species as large bodied skinks which are common throughout disturbed and forested areas from near sea level to 500 or 600 m asl. It can be found under rotting logs and shaded area with some leaf litters available throughout disturbed and forested areas (Alcala, 1980).

Sphenomorphus acutus was found in exotic tree plantation and secondary forest with 2 individuals. It is an arboreal species and often inhabits low elevations (Denzer, 1994). Dapar and Patindol (2008) observed that this species seems to be adapted to waterlogged areas with vegetation since the two specimens were collected on a rotting log with moist vegetation. Sanguila *et al.* (2016) found this species asleep in suspended coils of dry wild banana and abaca leaves that hanged 1–2 m above the forest floor and was observed retreating into running forest streams when pursued by field workers.

Sphenomorphus fasciatus was found only in exotic tree plantation dominated by *Swietenia macrophylla* with only 1 individual. This species is common in disturbed, second growth, and original coastal forests at low elevations (Sanguila *et al.*, 2016 after Brown and Alcala, 1980).

Fig. 2 showed the abundance of skinks species in terms of the number of individuals recorded as influenced by land-use systems. Majority of the skink species were found in agroforestry (56%) while native tree plantation and secondary forest harbored the least number of skink species (12%). One of the possible reasons that could explain such result is that the agroforestry site acted as an ecotone. Ecotones are dynamic boundaries and transitional areas between two very distinct ecological habitats containing different communities and physiochemical features (Thorp, 2015). Changes in microclimate such as light, temperature, moisture and wind conditions at forest edges are also associated with changes in the structure and composition of the existing plant communities (Mullu, 2016). Some animals even appear to prefer edges as suitable breeding habitat, despite the fact that mortality rates at edges can be much higher than in fragment interiors. It was also observed that the agroforestry site is warmer and had many open sunny patches where most skink species were seen basking as ectothermic animals. Another reason could also be attributed by microhabitat selection. Martin and Lopez (1999b and 2002) cited that microhabitat selection could explain the persistence of lizard populations in fragmented habitat although both the patterns and the fitness consequences of microhabitat selection vary in spatial and temporal aspects in relation to variation in predation risk, food availability, opportunities for thermoregulation and other components of habitat quality.

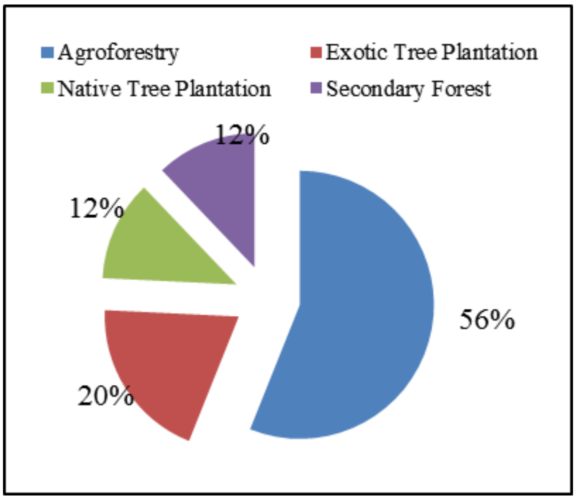

Fig. 2. Abundance of skink species as influenced by land use systems.

Species Diversity

Fig. 3 illustrated the species richness, diversity, and evenness indices of skink species as influenced by land-use systems. In terms of taxonomic diversity, exotic tree plantation and secondary forest had relatively comparable diversity indices (H'=0.4736; H'=0.4662) and species richness (R_2=0.3077; R_2=0.3750) while agroforestry had the lowest diversity index (H'= 0.1446) and species richness (R_2=0.0811). Further, exotic tree plantation, native tree plantation and secondary forest also had comparable evenness indices (E_s=0.7866; E_s=0.7619; E_s=0.7743) whereas agroforestry also had the lowest evenness index (E_s=0.3360).

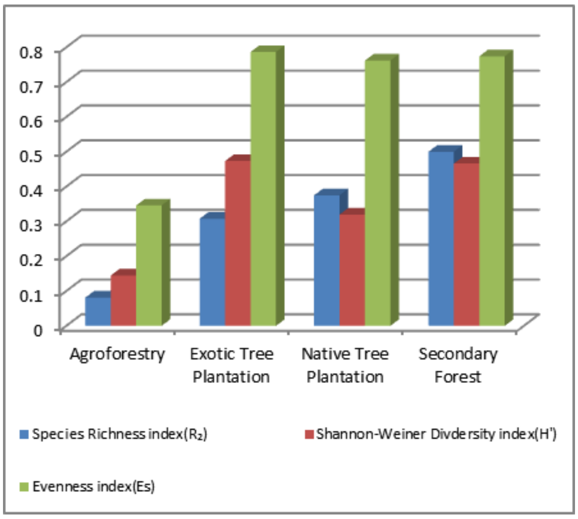

Fig. 3. Species richness (R2), diversity (H'), and evenness (Es) indices of skink species as influenced by land use systems.

Possible reasons that could explain these differences are habitat structure being provided by the land cover type and, to some extent, human impact. Jesse *et al.* (2018) found out that functional diversity was highest in nonforested environments on Caribbean islands, and further increased on St. Martin with the establishment of functionally unique exotic species in nonforested habitat. Habitat structure, rather than human impact, proved to be an important agent for environmental filtering of traits, causing divergent functional trait values across forested and nonforested environments. He further cited that traits which enhance survival in hot and open areas of potentially variable food availability appeared to be favored in nonforested environments including shrub and urban habitats. For example, body size is positively correlated with desiccation-tolerance and thermo-regulatory efficiency in reptiles (Dzialowski and O'Connor, 1999; Herczeg *et al.*, 2007). Preferred temperature is significantly related to heat tolerance (Llewelyn *et al.*, 2016), so it is likely that species that perform well at high temperatures can also survive higher temperatures for longer periods of time.

Moreover, findings of the study were surprising because of the widespread notions that monoculture of exotic trees does not support the survival of wildlife species of the Philippine rainforest that leads to biodiversity loss (Milan, undated), and that mahogany [*Swietenia macrophylla* (L.) Jacq.)] plantations are like green deserts to wildlife (Baguinon *et al.*, 2003). It seemed that these assumptions do not hold true for ectotherms, particularly scincid lizards. In fact, the species *Sphenomorphus fasciatus* was found only in exotic tree plantation that is dominated by *Swietenia macrophylla*. Bremer and Farley (2010) argued that exotic plantations do support some biodiversity, even when compared to primary forest, and should not necessarily be considered 'green deserts' or completely dismissed by conservation biologists. Although plantations often support fewer specialist species than natural ecosystems, they can play an important role in biodiversity conservation and recuperation under some conditions, particularly at the landscape level.

Conclusion

A total of 6 skink species in 4 genera with 66 individuals were recorded in this study. The genus *Sphenomorphus* was represented by *Sphenomorphus acutus* Peters (Point- headed Sphenomorphus) and *S. fasciatus* Gray (Banded Spenomorphus). On the one hand, genus *Eutropis* was represented by *Eutropis multicarinata* Gray (Two–striped Mabuya), and *E.multifasciata* Kuhl (Many–lined sun skink). The rest of the genera, *Brachymeles* and *Pinoyscincus* are each represented by a single species, Brachymeles *orientalis* Brown (Elongate short–legged burrowing skink) and *Pinoyscincus jagori* Peters (Jagor's Spenomorphus), respectively. Among the species collected, *Eutropis* and *Sphenomorphus* were the most represented genera with 2 species each while *Brachymeles* and *Pinoyscincus* were the least represented genera with only 1 species each.

The genus *Eutropis* had the highest number of individuals encountered (49) while *Pinoyscincus* was the least with only 2 individuals.

The distribution, abundance, and occurrence of skink species were influenced by land use systems. *Eutropis multifasciata* was the widely distributed and the most abundant scincid lizard. It was found in all sampling sites with 49 individuals, which only means that *E. multifasciata* is a generalist species having a wide range of environmental tolerance and occupying different microhabitat types in forested and shrubby habitats even if such habitats are under cultivation and are degraded. Majority of the skink species were found in agroforestry (56%) while native tree plantation and secondary forest harbored the least number of skink species (12%).

In terms of species diversity, exotic tree plantation and secondary forest had relatively comparable diversity indices (H'=0.4736; H'=0.4662) and species richness (R_2=0.3077; R_2=0.3750) while agroforestry had the lowest diversity index (H'= 0.1446) and species richness (R_2=0.0811). Further, exotic tree plantation, native tree plantation and secondary forest also had comparable evenness indices (E_s=0.7866; E_s=0.7619; E_s=0.7743) whereas agroforestry also had the lowest evenness index (E_s=0.3360). Findings of the study were surprising because of the widespread notions that monoculture of exotic trees does not support the survival of wildlife species of the Philippine rainforest (Milan, undated), and that *Swietenia macrophylla* plantations are like green deserts to wildlife (Baguinon *et al.*, 2003). It seemed that these assumptions do not hold true for ectotherms, particularly scincid lizards. In fact, the species *Sphenomorphus fasciatus* was found only in exotic tree plantation that is dominated by *Swietenia macrophylla.*

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