Assessment of herpetofauna and mammals in the Leyte Sab-a Basin Peatland, Philippines

Libertine A.F. Densing, Heremerose E. Matutes

Department of Environmental Science, Visayas State University-Alangalang, Leyte, Philippines

SUMMARY

Reliable biodiversity baseline data are needed to support the monitoring of faunal responses to human activities and the development of species conservation strategies in the Leyte Sab-a Basin Peatland (LSBP). We conducted a ten-day Rapid Biodiversity Assessment (RBA), the first survey of amphibians, reptiles, and mammals to focus specifically on the LSBP. We recorded 24 herpetofauna (17 reptile, seven amphibian) and eight mammal species. Four reptiles were Vulnerable and Near Threatened species according to the IUCN Red List, and another five were classified as Other Threatened species at national level. A possible new location record for Leyte Island was the Indo-Pacific tree gecko (*Hemiphyllodactylus typus* Bleeker 1860). Four of the mammal species we recorded also belonged to the IUCN and national Vulnerable, Endangered or Near Threatened categories. Our results showed that the LSBP is an important area for biodiversity conservation, hosting endemic and globally threatened species. Creating a Local Conservation Area (LCA) within or near the LSBP could substantially support the survival of threatened species that depend mostly on the peatland as their habitat. Nonetheless, further scientific studies are needed to better understand the value of the LSBP and how to conserve its natural resources.

KEY WORDS: biodiversity, fauna, IUCN Red List, threatened species, vulnerable species, tropical peatland

INTRODUCTION

Biodiversity is a vital attribute of ecosystems because different species form essential links in the food web and in nutrient cycles, which means that removal of even one species may potentially disrupt the entire ecosystem. Species differ in their sensitivity to environmental stressors, and thus environmental change including climate change has become the biggest global threat to biodiversity (Leo *et al.* 2020). Biodiversity assessment collects data on community structure, diversity, abundance, distribution, population dynamics and trophic structures, providing valuable information about habitats in vulnerable locations and permitting the identification of species that are in long-term decline. Faunal community composition, distribution, relative abundance and trophic guilds depend upon habitat characteristics such as size, water quality and the availability and distribution of food, water and sites for breeding and resting. Thus, the community of fauna present in an ecosystem broadly reflects the diversity and variability of available habitat types as well as land use (Wiens 1989).

Peatland ecosystems provide environmental and economic benefits such as carbon accumulation, climate regulation, biodiversity conservation, water conservation, food and biofuel (Chin *et al.* 2012, Turetsky *et al.* 2012, Yang *et al.* 2017). They differ from other ecosystems in that they accumulate energy, matter and information through geological time (Minayeva *et al.* 2017). Peatlands in their natural state have exceptional structural and functional integrity that offers an extensive range of habitats (e.g., bog, fen, swamp, marsh, pool and pond), creating specific environmental conditions that determine the uniqueness of their biodiversity (Minayeva & Sirin 2012, Biancalani & Avagyan 2014, Harrison & Rieley 2018, Leo *et al.* 2020). These ecosystems are important for biodiversity conservation because they support a range of plants and animals that includes many threatened and endemic species as well as migratory birds; and as natural gene banks they preserve potentially useful plant species (UNDP 2006, Jusoff *et al.* 2007, Parish *et al.* 2008, Chin *et al.* 2012). Nonetheless, information on species presence within peatland areas is scant (Husson *et al.* 2018), which hampers the development of conservation and monitoring strategies (Chin *et al.* 2012).

Peatlands in Southeast Asia represent approximately 56 % of the world's tropical peatland area and contain 77 % of the tropical peat carbon pool (Page *et al.* 2011, Dommain *et al.* 2015) and are amongst the region’s most vulnerable ecosystems; yet the study of peatlands in the Philippines has been neglected hitherto (Harrison & Rieley 2018). At the time of writing, there are still only two confirmed forested peatlands the Philippines, namely the Agusan Marsh on Mindanao Island and the Sab-a Basin peat swamp on Leyte Island (SEApeat 2011, PAWB-DENR 2020). The Leyte Sab-a Basin Peatland (LSBP) comprises a series of swamps and marshes exhibiting diverse and unique landscape features (Figure 1) and is Leyte's most significant hydrological catchment area (ADB 2000). Drainage and conversion of LSBP land to agricultural use, specifically rice production, has reduced the peatland's forest cover. Some areas have become uncultivable and have been abandoned by local farmers. Conversion of the peatland may also have resulted in degradation characterised by the loss of important species from its flora and fauna, negative effects on ecological services (ADB 2000) and alterations to physicochemical properties of the peat soil (Decena *et al.* 2021).

The Philippines hosts a highly diverse herpetofauna (Diesmos *et al.* 2002, Das & van Dijk 2013, Diesmos *et al.* 2020) with an estimated total of 359 amphibian and reptile species of which 68 % are endemic to the country. These species are now under pressure, and some may be threatened with extinction, as a result of massive deforestation of the Philippine lowlands (Diesmos 2008). The Philippines has a similarly diverse mammalian fauna and a greater proportion of endemic mammal species than any other country. Heaney *et al*. (1998) recorded 172 terrestrial mammal species of which 111 were endemic, and these estimates have since increased substantially (Heaney *et al*. 2016). The challenges presented by climate change, habitat loss and degradation, environmental pollution and introduced invasive species will affect herpetofauna and mammalian diversity; and climate change could even alter the metabolism of herpetofauna, driving them towards extinction, because they are heterothermic (Gibbons *et al.* 2000, Hansen *et al.* 2001, Bickford *et al.* 2010, Leo *et al*. 2020).

Previously, the most recent documented assessment of faunal distribution and diversity in the LSBP was carried out more than 20 years ago as part of a national assessment of wetland areas (ADB 2000) and was never published. The lack of suitable baseline data placed limitations on our ability to develop species conservation strategies and monitor the effects of human activities on the biodiversity of the area. Therefore, we carried out a new study to determine the current species composition and conservation status of herpetofauna and mammals occurring in the LSBP.

Figure 1. Overview of the peat swamp forest in the Leyte Sab-a Basin, as seen from Barangay Tabangohay (Municipality of Alangalang). This region has remained mostly untouched by human activity. Photo credit: Juvylyn Salazar.

METHODS

Study area

The Leyte Sab-a Basin (3,088 ha) is located in the north-eastern part of Leyte Island. It is elongated in a NW–SE direction and stretches across the four barangays (village-level administrative areas) of Langit, Divisoria, Tabangohay and Veteranos in the municipality of Alangalang, two barangays (San Isidro, Gapas) in the municipality of Santa Fe to the south, and two barangays (Capilihan, Guinciaman) in the municipality of San Miguel to the north (Garcia *et al.* 2018). The underlying geology is tectonic in origin with a parent material of recent volcanic alluvial deposits derived from metamorphic rocks and sedimentary sequences (ADB 2000, Suerte *et al.* 2005), and forms extensive depressions at the base of the metamorphic uplands along the basin’s eastern margin. The extreme north-western part of the basin is partly isolated from the central part by a ridge running southwards into the basin. Soils to the east of the ridge are classified as Tacloban Ophiolite Complex, and those to the west are Palo clay/loam. The Dolongan peat is found primarily in the central portion of the basin, bounded along its edges by deposits of mineral soil eroded from the topographical ridges that define the surrounding hydrological catchment (ADB 2000).

According to the Corona Climate Classification System (Lantican 2001, Decena *et al.* 2020), the Leyte region is classified as Type IV, characterised by only slight variation in temperature and more or less evenly distributed rainfall throughout the year. There is no dry season. The average monthly rainfall is > 400 mm for the wettest month (December) and 150 mm for the driest month (April) (Quiñones & Asio 2015, Corporal-Lodangco & Leslie 2017). Surface runoff enters the Leyte Sab-a Basin from the uplands on its eastern side, and two river systems, namely the Bangon or Palo River and the Mainit River, collect water from its western flank. In the central and southern portions of the basin, three natural physical barriers prevent water from flowing into the inner part of the peatland (Garcia *et al.* 2018).

Study site

The total area of the LSBP is 2,107.65 ha, according to the most recent geoinformatics study (Garcia *et al.* 2018, Matutes & Densing 2022), and almost half of it has been reclaimed for agriculture (ASEANPEAT 2021). The highest elevation within the peatland is 17 m a.s.l. (at 11.26 ºN, 124.90 ºE), where it crosses a watershed near Tabangohay (Alangalang). On the edge of the LSBP near San Isidro (Santa Fe), 7.2 km from the watershed, the elevation is 12 m a.s.l., meaning the average southward slope between these two points is 0.069 %. The peatland edge along the Sangputan River near Tabangohay lies at approximately 11 m a.s.l., 2.2 km from the highest point, making the average slope in this direction 0.27 % (Garcia *et al*. 2018).

The General Land Use and Vegetation Map of the LSBP (Garcia *et al.* 2018, Matutes & Densing 2022) identifies four main land use/vegetation classes within the LSBP (Figure 2). The classes are: peat swamp forest (dominant species are the trees *Terminalia copelandii*, *Nauclea orientalis* and *Metroxylon sagu*); grasses and sedges (the dominant plant species are *Scleria scobiculata*, *Fimbristylis globulosa* and *Cyperus trachysanthos*); grasses and sedges with cultivation; and pools with hydrophytes. A significant portion of the land classified as peat swamp forest is located in the northern and central parts of the peatland in Barangays Tabangohay (410 ha) and Divisoria (291.54 ha) (Alangalang). In Santa Fe, most of the vegetation belongs to the grasses and sedges class, observed mainly in Barangay San Isidro (167.66 hectares) where some portions of the rice fields have been abandoned due to poor yield and, in some other places, root crops like *Alocasia macrorhizuz* are cultivated. San Miguel has mixed vegetation types; the total area of peat swamp forest in Barangay Guinciaman is 148.11 ha, whereas in Barangay Capilihan, the primary vegetation class is grasses and sedges and the dominant plant species is *Fimbristylis globulosa*.

Background biodiversity data

Published literature, websites and reports on Leyte's biodiversity were reviewed. Key references were the biodiversity baseline assessment carried out in Southern Leyte by Mallari *et al.* (2013), the account of mammalian diversity on three Philippine islands (including Leyte) by Rickart *et al.* (1993), and online databases of herpetofauna and mammal records (AmphibiaWeb 2020, ASM 2020, Uetz & Hallermann 2020). We also consulted publications on Philippine amphibians (Inger 1954, Diesmos *et al.* 2015, ISSG 2021), snakes (Sy *et al.* 2009, Leviton *et al.* 2018, Weinell *et al.* 2019) and lizards (Brown & Alcala 1980, Deso *et al*. 2007, Deso *et al*. 2020), the Southeast Asian Box Turtle (Schoppe & Das 2011, Binaday & Sarmiento 2020) and the Philippine Deer (Wiles 2012). To supplement this information, we conducted ethnobiological and Key Informant interviews with local people to discover additional known locations or possible sightings of target species. This approach allowed us to compile detailed field checklists for amphibians, reptiles, and mammals previously recorded on Leyte.

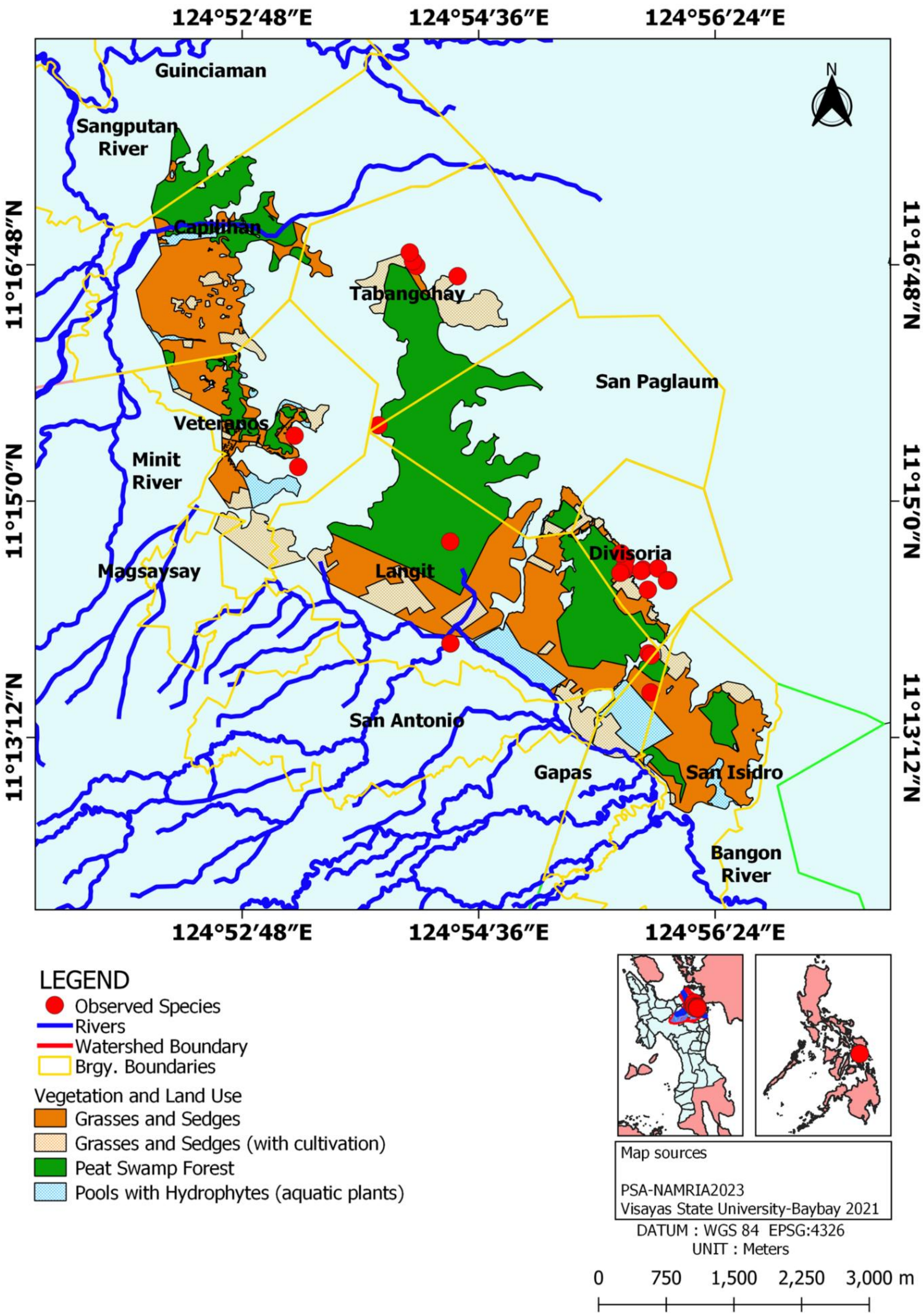

Figure 2. Map of the main ecotypes (vegetation and land use categories) of the LSBP from (our own) General Land Use Map, with the sites for herpetofauna and mammal assessments superposed (red spots). The yellow lines divide the peatland into areas falling within the boundaries of different barangays (village administrations), derived from the PhilGIS geoportal (https://www.geoportal.gov.ph/).

We referred to the IUCN Red List (IUCN 2020) for global conservation status, which provides comprehensive information on the extinction risk of species worldwide. We also consulted the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) checklist CITES 2021) to understand the regulations regarding the international trade of endangered species. Specifically, "CITES A-II" refers to Appendix II of the CITES, which lists species that are not necessarily in danger of extinction but may become so unless trade is closely controlled.

We also utilised information on the National Conservation Status of the Philippines, such as the publication of Gonzalez *et al.* (2004), which provided valuable insights into the national conservation status and biodiversity of the Philippines; a publication from the Department of Environment and Natural Resources (DENR 2019) which offered updated national conservation statuses and regulatory measures; and one from the Biodiversity Management Bureau (BMB 2020) which provided additional national-level information on species conservation. To identify Key Biodiversity Areas (KBAs) and trigger species, we referred to relevant conservation frameworks and databases that outline criteria for KBA designation, ensuring the protection of critical areas for global biodiversity conservation.

Field data collection

In total, 29 sampling sites within the LSBP were selected to represent the four main land use/vegetation classes (Figure 2). Field data were collected over ten days from 31 March to 09 April 2021. Gratuitous Permits (GP Nos. RO8 2018-23 and 2021-06) were secured beforehand via DENR-Leyte (Philippines Department of Environment and Natural Resources). Field survey methods followed the guidelines for rapid biodiversity assessment (RBA) in terrestrial and marine environments provided by the National Biodiversity Management Bureau (BMB 2017) and the Secretariat of the Pacific Regional Environment Programme (SPREP 2014). We also consulted the Convention on Biological Diversity (CBD) methodological guidelines (CBD 2006). The methods adopted were (1) Baseline Inventory focusing on the overall biological diversity rather than extensive or detailed information about specific taxa or habitats and (2) Species-Specific Assessment to provide rapid appraisals of the status of particular species or taxonomic groups in each area.

We applied various standardised sampling procedures appropriate to the vegetation types at the 29 sampling sites, such as Visual Encounter Survey (VES) transect walks and opportunistic sampling methods. Each procedure was tailored to ensure effective data collection suited to the specific characteristics of the vegetation present. For instance, visual encounter surveys (VES) (Maulidi *et al.* 2019) and mist nets were deployed at different canopy levels in forested areas. In contrast, we used transect walks in open grasslands. This approach ensured that our sampling was consistent and adapted to the ecological context of each site.

Visual Encounter Surveys (VES) and transect walks were used for the herpetofauna assessment. Opportunistic sampling was employed to ensure comprehensive data collection coverage across different habitats and conditions. Diurnal surveys were conducted from 09:00 to 11:00 and nocturnal surveys from 19:00 to 01:00. For ground-level assessments we thoroughly searched the forest floor, leaf litter, fossorial deposits and waterlogged areas. Arboreal habitats including trees, ferns, vines, axillae of Pandanaceae and holes in trees were also investigated to cover all potential microhabitats. To avoid recapturing the same individual, we applied toenail clipping (Phillott *et al.* 2007) to mark the captured individuals.

For the mammal survey we recorded trail marks, tracks and droppings, feathers, skulls and any other indicators. For bats, mist nets (mesh size 15 mm) were placed strategically at various heights and locations to maximise capture rates. The mist nets were deployed before dusk and left undisturbed for eight hours (for example, 18:00–02:00) to capture peak bat activity. The area covered at each site was approximately 1 km^2, ensuring a comprehensive assessment of bat populations. Captured bats were handled carefully using gloves and placed in soft cloth bags for measurement and identification before release. Detailed records were made for each bat including species, measurements and capture location.

Voucher specimens were collected and housed at Visayas State University-Alangalang. Collected specimens were subjected to meristic and morphometric measurements including photographic documentation, and this information was deposited with each voucher specimen. Individuals of notable species such as the Sailfin Lizard, Samar Water Monitor Lizard and Philippine Tarsier that were encountered were also geo-tagged and photographed.

RESULTS

Our amphibian, reptile and mammal species checklists are provided as Tables A1, A2 and A3 in the Appendix. At the LSBP we recorded 24 herpetofauna species representing five amphibian and eight reptile families, and eight mammal species representing seven families (Table 1). These included 14 species that are endemic to the Philippines (amphibians: Philippine Sticky Frog, Painted Narrow-Mouth Toad, Figure 3; reptiles: Reinhardt's Lined Snake, Maren's Bonzeback, Samar Cobra, Philippine Shrub Snake, Philippine Ground Snake (Figure 4), Reticulated Flying Lizard, Samar Water Monitor, Sailfin Lizard, Emerald Green Tree Skink; mammals: Philippine Brown Deer, Philippine Warty Pig, Philippine Tarsier).

Four of the 17 reptiles that we found in the LSBP are IUCN Vulnerable or Near Threatened species (King Cobra, Philippine Ground Snake, Sailfin Lizard, Southeast Asian Box Turtle; Figure 4), and five more are classified as Other Threatened species at national level according to DENR (2019) (Reddish Rat Snake, Samar Cobra, Green Crested Lizard, Samar Water Monitor, Tokay Gecko). Notably, the Indo-Pacific Tree Gecko (*Hemiphyllodactylus typus* Bleeker 1860) is a possible new location record for Leyte; its currently recorded Philippine distribution encompasses only the islands of Panay, Mindoro, Bohol and Cebu (Uetz & Hallermann 2020). Of the eight mammal species recorded in our field survey, four are classified as Vulnerable, Endangered or Threatened by IUCN (2020) and/or DENR (2019) (Philippine Tarsier (Figure 5), Long-Tailed Macaque, Philippine Warty Pig, Philippine Brown Deer). Three KBA trigger species which are also endemic to the Philippines were recorded, namely the Philippine Ground Snake, Philippine Brown Deer and Philippine Warty Pig. The presence of KBA trigger species is critical as it highlights the area's importance for biodiversity conservation. These species can be used to build a case for the designation of new Key Biodiversity Areas (KBAs) at LSBP, underscoring their ecological significance. KBAs are sites that contribute significantly to the global persistence of biodiversity based on the presence of species that are globally threatened, restricted-range, biome-restricted or congregatory (Gerlach 2008, Eken *et al.* 2016, Langhammer *et al.* 2018, Smith *et al.* 2018, Nogueira *et al.* 2021).

DISCUSSION

Southeast Asian islands are characterised by high endemicity (Das & van Dijk 2013), and biodiversity in the Philippines is vastly underestimated (Brown & Diesmos 2009). Hence, studies like ours are essential to improve our understanding of the country's biodiversity. Because there were previously no published records of the species composition of mammal and herpetofauna communities in the LSBP, this study contributes significant new information on species diversity in the region and the country, and indicates the potential of this peatland to yield new species location records. Despite the short period of sampling effort, we demonstrated high species richness of herpetofauna and mammals and a high number of endemic species. Whereas the unpublished assessment by ADB (2000) recorded only five herpetofauna and five mammal species in LSBP, we found 32 % (6) of the amphibians, 40 % (16) of the reptiles and 24 % (8) of the mammals listed for Southern Leyte by Mallari *et al.* (2013), and 16 % of the mammals reported from Leyte by Rickart *et al.* (1993).

The discovery of the Indo-Pacific Tree Gecko (*Hemiphyllodactylus typus*) as a new location record for Leyte is particularly noteworthy. This finding extends the known distribution of this species, which was previously recorded only on the islands of Panay, Mindoro, Bohol and Cebu (Uetz & Hallermann 2020). To validate this new record, it is essential to conduct follow-up surveys and genetic analyses to confirm the species' identity and its potential establishment in Leyte. Such data should be submitted to relevant national and international biodiversity databases, such as the Global Biodiversity Information Facility (GBIF) and the Philippine Biodiversity Management Bureau (BMB), to ensure that it is included in official checklists and conservation assessments.

While our study has provided valuable insights into the herpetofauna and mammal communities at LSBP, given the high biodiversity and endemicity of the region it is likely that our Rapid Biodiversity Assessment (RBA) may not have captured the full species richness present in the LSBP. This is particularly true in biodiverse regions like the Philippines, where extended and detailed fieldwork has historically led to the discovery of many new species (Heaney *et al.* 1989). The previous studies by Heaney and colleagues have demonstrated that extended and intensive surveys involving thorough trapping often reveal higher species diversity than is initially recorded, with researchers sometimes spending months in relatively small areas to document the full extent of biodiversity (Rickart *et al.* 1991, Bogdan *et al.* 2016). On this basis, we estimate that our current findings may represent only a fraction of the total species present in the LSBP. To uncover this area's full spectrum of mammals, more intensive trapping studies are required, particularly in less accessible or previously unexplored microhabitats. The relatively untouched peat swamp

Table 1. List of amphibian, reptile and mammal species identified during this study of the LSBP. Shading indicates endemic species. A bullet in the Conservation Status (Cons. Status) column indicates that the species is classified as Vulnerable (VU), Near Threatened (NT) or Other Threatened Species (OTS) by IUCN (2020) and/or DENR (2019) and BMB (2020).

		Family	Species	Cons. Status
Amphibians		Microhylidae	*Kalophrynus sinensis* Peters 1867	
			Kaloula picta Duméril and Bibron 1841	
		Dicroglossidae	*Fejervarya vittigera* Wiegmann 1834	
			Occidozyga laevis Günther 1858	
		Bufonidae	*Rhinella marina* Linnaeus 1758	
		Ranidae	*Hylarana erythraea* Schlegel 1837	
		Rhacophoridae	*Polypedates leucomystax* Gravenhorst 1829	
Reptiles	snakes	Colubridae	*Stegonotus muelleri* Duméril, Bibron and Duméril 1854	●
			Coelognathus erythrurus Duméril, Bibron and Duméril 1854	●
			Dendrelaphis marenae Vogel & Van Rooijen 2008	
			Cyclocorus lineatus Reinhardt 1843	
		Lamprophiidae	*Oxyrhabdium modestum* (Duméril, Bibron & Duméril 1854)	
		Elapidae	*Naja samarensis* Peters 1861	●
			Ophiophagus hannah Cantor 1836	●
	lizards	Varanidae	*Varanus samarensis* Koch, Gaulke & Böhme 2010	
		Scincidae	*Eutropis multifasciata* Kuhl 182	
			Eutropis multicarinata Gray 1845	
			Lamprolepis smaragdina Lesson 1830	
		Gekkonidae	*Gekko gecko* Linnaeus 1758	●
			Hemiphyllodactylus typus Bleeker 1860	
		Agamidae	*Draco reticulatus* Günther 1864	
			Hydrosaurus pustulatus Eschscholtz 1829	●
			Bronchocela cristatella Kuhl 1820	●
	turtle	Geoemydidae	*Cuora amboinensis* Riche in Daudin 1801	●
Mammals		Tarsiidae	*Tarsius syrichta* Linnaeus 1758	●
		Cercopithecidae	*Macaca fascicularis philippinensis* I. Geoffroy Saint-Hilaire 1843	●
		Suidae	*Sus philippensis mindanensis* Forsyth Major 1897	●
		Cervidae	*Rusa marianna* Desmarest 1822	●
		Viverridae	*Paradoxurus hermaphroditus philippinensis* Jourdan 1837	
		Muridae	*Rattus tanezumi* Temminck 1845	
		Pteropodidae	*Cynopterus luzoniensis* Peters 1861	
			Ptenochirus minor Yoshiyuki 1979	

Philippine Sticky Frog
Kalophrynus sinensis Peters 1867

Painted Narrowmouth Toad
Kaloula picta Duméril and Bibron 1841

Figure 3. Endemic amphibian species found in LSBP. Photographs of other amphibians recorded during our survey are provided in Figure A1 in the Appendix.

Philippine Ground Snake
Stegonotus muelleri Duméril, Bibron and Duméril 1854

Southeast Asian Box Turtle
Cuora amboinensis Riche in Daudin 1801

Sailfin Lizard
Hydrosaurus pustulatus Eschscholtz 1829

Figure 4. IUCN (2020) Vulnerable and Near Threatened reptile species found in the LSBP. Photographs of other reptiles recorded during our survey are provided in Figures A1 and A2 in the Appendix.

forest, especially in the centre of this peatland area, could potentially give us more species of herpetofauna as well as other fauna and flora. Given our findings and the high biodiversity of the region, it is reasonable to estimate that detailed studies could uncover at least 20–30 % more species of herpetofauna and mammals in the LSBP. Our RBA results can guide future research efforts to the most promising locations within the LSBP, focusing on areas with intact peatland habitats that have shown high species diversity and endemism.

Our assessment of LSBP herpetofauna and mammals addressed a knowledge gap regarding the peatland's fauna. It provided baseline information to support the development of an integrated management and conservation plan for the sustainable development of the LSBP, as well as important conservation decisions for the Local Government Unit, stakeholders, lawmakers and local communities. This study confirms that the LSBP is an important area for biodiversity conservation, hosting endemic and globally threatened animal

Philippine Tarsier
Tarsius syrichta Linnaeus 1758

Philippine Warty Pig
Sus philippensis mindanensis Forsyth Major 1897

Figure 5. Mammal species found in the LSBP that are Vulnerable, Endangered or Threatened (nationally or internationally) according to DENR (2019) and/or IUCN (2020). We did not observe any live specimens of Philippine Warty Pig but we found pig tracks at almost all of our sampling sites and were shown the photographed collection of skulls by a local hunter. Photographs of other mammals recorded during our survey are provided in Figure A3 in the Appendix.

species. Most of these were recorded within areas of peatland habitat that are still intact, where the highest diversity and densities of critical species are to be found. We cannot disregard the 14 (of 24) species whose conservation status is already Endangered, Vulnerable or Near-Threatened because they have a role to play in maintaining the ecological balance and overall health of the peatland. The presence of the iconic Philippine Tarsier, along with the other (inter)nationally vulnerable and/or threatened mammals - the Long-Tailed Macaque, Philippine Brown Deer and Philippine Warty Pig - could be especially important in building a case for statutory protection of the LSBP and/or establishing a Local Conservation Area (LCA) in its vicinity.

To build on our initial findings, we recommend a series of follow-up studies employing a combination of trapping, camera traps and acoustic monitoring to document the mammal species in the LSBP systematically. Additionally, more detailed surveys of herpetofauna using pitfall traps, visual encounter surveys and environmental DNA (eDNA) analysis would help to identify elusive and cryptic species. We also recommend that the establishment of an LCA should start on the relatively intact peat swamp forest within the Municipality of Alangalang, where the highest diversity and densities of critical species were recorded. Notably, this area is home to key biodiversity area trigger species such as the Blue-naped Parrot (*Tanygnathus lucionensis*), Rufous Hornbill (*Buceros hydrocorax*), Philippine Duck (*Anas luzonica*), Philippine Hanging Parrot (*Loriculus philippensis*) and Azure-breasted Pitta (*Pitta steerii*) (Matutes & Densing 2022). It also hosts, from this study, the new location for the Indo-Pacific Tree Gecko along with endangered mammals such as the Philippine Warty Pig and Philippine Brown Deer. Therefore, this location would provide a strong foundation for biodiversity conservation and serve as a focal point for further research and conservation efforts.

Unfortunately, almost all barangays adjacent to the peatland practice wildlife hunting. The Philippine Tarsier, Samar Water Monitor and Philippine Warty Pig are particularly prized for the pet trade and/or for their meat, and are hunted regularly. Indeed, hunting is currently the greatest threat to maintaining the ecological balance of the entire peatland forest. Regrettably, this kind of ecological malpractice is still continuously embraced by new generations, reflecting insufficient local knowledge of the importance of nature conservation. Other substantial threats to the peatland forest ecosystem observed during our study include mono-crop agriculture and the Kaingin system of shifting 'slash-and-burn' cultivation. Sadly, these issues are not restricted to Leyte, as peatland ecosystems throughout Southeast Asia are under intense pressure from logging, fire, and land conversion (Posa *et al.* 2011). Newly emerging human pressures such as road widening, quarrying, reclamation and land conversion can only reinforce the vulnerability of the remaining areas of undisturbed peatland to potentially catastrophic degradation.

To mitigate these threats and change the hearts and minds of local people, it is crucial to give biodiversity some commercial value by creating jobs in local conservation and ecotourism. Local communities can be encouraged to become more invested in protecting their natural heritage by demonstrating the economic benefits of biodiversity conservation, such as ecotourism initiatives and employment in conservation projects. This approach can help to reduce wildlife hunting and other detrimental practices by providing alternative livelihoods that benefit both people and the environment.

The information gathered during our study provides a more comprehensive inventory of the species present in the LSBP than was available previously, and will inform conservation strategies and policy decisions to protect this critical habitat. Overall, our study provides a crucial baseline for understanding the biodiversity of the LSBP, and underscores the need for further detailed research to fully document and conserve the rich fauna of this unique peatland ecosystem.

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AUTHOR CONTRIBUTIONS

LAFD prepared the research proposal, collected data, and finalised the manuscript. HEM contributed to the sampling design and data collection. Both authors carried out data analyses and contributed substantially to the development of the manuscript.

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Author for correspondence:
Libertine Agatha F. Densing, Visayas State University - Alangalang, Brgy. Binongtoan, Alangalang, Leyte, 6517 Philippines. Tel: +639177025730; Email: libertine.densing@vsu.edu.ph

Appendix

Table A1. Checklist of amphibian species for Leyte Island. Codes appended to scientific names: a = endemic. Species identified by this study (LSBP 2021), Malari *et al*. (2013) (Mal 2013) and AmphibiaWeb (2020) (AW 2020) are indicated. Conservation status categories: DD = Data Deficient, LC = Least Concern, NT = Near Threatened, VU = Vulnerable, OTS = Other Threatened Species (DENR 2019, IUCN 2020).

No	Common Name	Scientific Name	LSBP 2021	Mal 2013	AW 2020	Conservation status	
						IUCN 2020	DENR 2019
1	Asian Brackish Frog	*Fejervarya cancrivora*		+	+	LC	-
2	Crab-eating Frog	*Fejervarya moodiei*			+	DD	-
3	Luzon Wart Frog	*Fejervarya vittigera*	+	+	+	LC	-
4	Common Green Frog	*Hylarana erythraea*	+		+	LC	-
5	Black-spotted Narrow-mouthed Frog	*Kalophrynus pleurostigma*		+		LC	
6	Philippine Sticky Frog	*Kalophrynus sinensis* (a)	+	+	+	-	-
7	Philippine Narrowmouth Toad	*Kaloula conjuncta*			+	LC	-
8	Painted Narrowmouth Toad	*Kaloula picta* (a)	+		+	LC	-
9	Philippine Flying Frog	*Kurixalus appendiculatus*		+	+	LC	-
10	Leyte Wart Frog	*Limnonectes leytensis*		+	+	LC	-
11	Mindanao Fanged Frog	*Limnonectes magnus*		+	+	NT	OTS
12	American Bullfrog	*Lithobates catesbeianus*			+	LC	-
13	Mindanao Horned Frog	*Megophrys stejnegeri*		+	+	LC	OTS
14	Spiny Indonesian Treefrog	*Nyctixalus spinosus*		+	+	LC	-
15	Puddle Frog	*Occidozyga laevis*	+	+	+	LC	-
16	Mindanao Cross Frog	*Oreophryne anulata*			+	LC	-
17	Eastern Mindanao Dwarf Toad	*Pelophryne lighti*		+	+	LC	-
18	Mindanao Bush Frog	*Philautus leitensis*		+	+	LC	-
19	Smooth-skinned Tree Frog	*Philautus worcesteri*			+	LC	VU
20	Walter’s Limestone Forest Frog	*Platymantis bayani*		+	+	DD	-
21	Rough-backed Forest Frog	*Platymantis corrugatus*		+	+	LC	-
22	Dumeril's Wrinkled Ground Frog	*Platymantis dorsalis*			+	LC	-
23	Gunther's Wrinkled Ground Frog	*Platymantis guentheri*		+	+	LC	-
24	Rabor's Forest Frog	*Platymantis rabori*		+	+	LC	VU
25	Common Tree Frog	*Polypedates leucomystax*	+	+	+	LC	-
26	Big-eyed Frog	*Pulchrana grandocula*		+	+	LC	-
27	Mindanao Flying Frog	*Rhacophorus bimaculatus*		+	+	LC	-
28	Panther Flying Frog	*Rhacophorus pardalis*		+	+	LC	-
29	Cane Toad	*Rhinella marina*	+		+	LC	-
30	Cabilian Frog	*Sanguirana mearnsi*		+	+	LC	-
31	Mindanao Splash Frog	*Staurois natator*		+		LC	

Table A2. Checklist of reptile species for Leyte Island. Codes appended to scientific names: a = endemic, b = KBA trigger species, c = species listed by CITES (2021). Species identified by this study (LSPB 2021), Malari *et al*. (2013) (Mal 2013) and Uetz & Hallermann (2020) (RD 2020) are indicated. Conservation status (Cons. Status) categories: DD = Data Deficient, LC = Least Concern, VU = Vulnerable NT = Near Threatened, OTS = Other Threatened Species (DENR 2019, IUCN 2020).

No	Common name	Scientific name	LSBP 2021	Mal 2013	RD 2020	Cons. Status	
						IUCN	DENR
1	Philippine Vine Snake	*Ahaetulla prasina*		+	+	LC	-
2	Blunt Head Slug Snake	*Aplopeltura boa*		+	+	LC	-
3	Philippine Blunt-headed Tree Snake	*Boiga angulata*			+	LC	OTS
4	Dog-toothed Cat Snake	*Boiga cynodon*		+	+	LC	OTS
5	Variable Reed Snake	*Calamaria lumbricoidea*		+	+	LC	-
6	Reddish Rat Snake	*Coelognathus erythrurus*	+	+	+	-	OTS
7	Reinhardt's Lined Snake	*Cyclocorus lineatus* (a)	+		+	LC	-
8	Southern Triangle-spotted Snake	*Cyclocorus nuchalis taylori*		+	+	LC	-
9	Gray Bronzeback	*Dendrelaphis caudolineatus*		+	+	-	-
10	Maren's Bronzeback	*Dendrelaphis marenae* (a)	+		+	DD	-
11	Philippine Bronzeback Tree Snake	*Dendrelaphis philippinensis*			+	-	-
12	Indian Wolf Snake	*Lycodon aulicus*		+	+	-	-
13	Common Wolf Snake	*Lycodon capucinus*			+	LC	-
14	Ferron's Asian Wolf Snake	*Lycodon ferroni*		+	+	DD	-
15	Reticulated Python	*Malayopython reticulatus*		+	+	LC	OTS
16	Reticulated Python	*Malayopython reticulatus*		+	+	LC	OTS
17	Samar Cobra	*Naja samarensis* (a, and c; A-II)	+	+	+	LC	OTS
18	Spotted-bellied Short-headed Snake	*Oligodon modestum*		+	+	VU	
19	King Cobra	*Ophiophagus hannah* (c; A-II)	+		+	VU	OTS
20	Philippine Shrub Snake	*Oxyrhabdium modestum* (a)	+	+	+	LC	-
21	Common Mock Viper	*Psammodynastes pulverulentus*		+	+	-	-
22	Smooth-scaled Mountain Rat Snake	*Ptyas luzonensis*			+	LC	OTS
23	White-lined Water Snake	*Rhabdophis auriculatus*		+	+	-	-
24	Zigzag-lined Water Snake	*Rhabdophis lineatus*			+	LC	-
25	Philippine Ground Snake	*Stegonotus muelleri* (a, b)	+		+	NT	-
26	Philippine Pitviper	*Trimeresurus flavomaculatus*		+	+	LC	OTS
27	North Philippine Temple Pit Viper	*Tropidolaemus subannulatus*		+	+	LC	OTS
28	Wagler's Keeled Green Pit Viper	*Tropidolaemus wagleri*		+	+	LC	-
29	Spotted Water Snake	*Tropidonophis dendrophiops*		+	+	LC	-
30	Negros Spotted Water Snake	*Tropidonophis negrosensis*		+	+	VU	-
31	Southern Burrowing Skink	*Brachymeles orientalis*		+	+	-	-
32	PAEF Slender Skink	*Brachymeles paeforum*		+	+	-	-
33	Eastern Visayas Slender Skink	*Brachymeles samad*			+	-	-
34	Short-legged Skink	*Brachymeles talinis*		+	+	LC	-
35	Green-crested Lizard	*Bronchocela cristatella*	+	+	+	-	OTS
36	Southeast Asian Box Turtle	*Cuora amboinensis* (c; A-II)	+	+	+	VU	OTS
37	Mindanao Bow-fingered Gecko	*Cyrtodactylus agusanensis*			+	LC	-
38	Curved-toed Gecko	*Cyrtodactylus gubaot*		+	+	-	-
39	Mindanao Flying Lizard	*Draco mindanensis*		+	+	VU	-
40	White-spotted Flying Lizard	*Draco ornatus*			+	LC	-
41	Reticulated Flying Lizard	*Draco reticulatus* (a)	+		+	LC	-
42	Two-striped Mabuya	*Eutropis multicarinata*	+	+	+	LC	-
43	Common Mabuya	*Eutropis multifasciata*	+		+	LC	-

No	Common name	Scientific name	LSBP 2021	Mal 2013	RD 2020	Cons. Status	
						IUCN	DENR
44	Tender-skinned House Gecko	*Gehyra mutilata*			+	-	-
45	Tokay Gecko	*Gekko gecko* (c; A-II)	+		+	LC	OTS
46	Dark-spotted Forest Dragon	*Gonocephalus semperi*		+	+	DD	OTS
47	Common House Gecko	*Hemidactylus frenatus*		+	+	LC	-
48	Indo-Pacific Tree Gecko	*Hemiphyllodactylus typus*	+		+	LC	-
49	Sailfin Lizard	*Hydrosaurus pustulatus* (a)	+	+	+	VU	OTS
50	Emerald Green Tree Skink	*Lamprolepis smaragdina* (a)	+		+	-	-
51	Cuming's Sphenomorphus	*Otosaurus cumingii*		+	+	-	-
52	Steere's Sphenomorphus	*Parvoscincus steerei*		+	+	-	-
53	Cox's Sphenomorphus	*Pinoyscincus coxi*		+	+	LC	-
54	Jagor's Sphenomorphus	*Pinoyscincus jagori*		+	+	LC	-
55	Leyte Sphenomorphus	*Pinoyscincus llanosi*			+	NT	-
56	Mindanao Sphenomorphus	*Pinoyscincus mindanensis*		+	+	NT	-
57	Philippine False Gecko	*Pseudogekko compressicorpus*		+	+	LC	-
58	Leyte Diminutive Gecko	*Pseudogekko ditoy*			+	-	-
59	Southern Philippine Gecko	*Pseudogekko pungkaypinit*			+	-	-
60	Philippine Flying Gecko	*Ptychozoon intermedium*			+	NT	OTS
61	Pointed-headed Sphenomorphus	*Sphenomorphus acutus*		+	+	LC	-
62	Banded Sphenomorphus	*Sphenomorphus fasciatus*		+	+	LC	-
63	Skink	*Sphenomorphus variegatus*		+	+	-	-
64	Gray's Keeled Skink	*Tropidophorus grayi*			+	LC	-
65	Cuming's Water Monitor	*Varanus cumingi*		+	+	LC	OTS
66	Samar Water Monitor	*Varanus samarensis* (a, c)	+		+	-	OTS

Table A3. Checklist of mammal species for Leyte Island. Codes appended to scientific names: a = endemic, b = KBA trigger species, c = species listed by CITES (2021). Species identified by this study (LSPB 2021), Malari *et al*. (2013) (Mal 2013) and Rickart *et al*. (1993) (Ric 1993) are indicated. Conservation status (Cons. Status) categories: DD = Data Deficient, LC = Least Concern, VU = Vulnerable NT = Near Threatened, OTS = Other Threatened Species (DENR 2019, IUCN 2020).

No	Common Name	Scientific Name	LSBP 2021	Mal 2013	Ric 1993	Cons. Status	
						IUCN	DENR
1	Golden-capped Flying Fox	*Acerodon jubatus*		+	+	EN	CR
2	Mindanao Lowland Apomys	*Apomys littoralis*			+	DD	-
3	Mindanao Batomys	*Batomys salomonseni*		+	+	LC	-
4	Mindanao Bullimus	*Bullimus bagobus*		+	+	LC	-
5	Wrinkled-lipped Free-tailed Bat	*Chaerephon plicata*			+	LC	VU
6	Mindanao Shrew	*Crocidura beatus*		+	+	LC	-
7	Mindanao Shrew Mouse	*Crunomys rabori*			+	LC	-
8	Philippine Flying Lemur	*Cynocephalus volans*		+	+	LC	-
9	Lesser Dog-faced Fruit Bat	*Cynopterus luzoniensis*	+	+	+	LC	-
10	Philippine Sheath-tailed Bat	*Emballonura alecto*		+	+	LC	-
11	Philippine Dawn Bat	*Eonycteris robusta*			+	LC	VU
12	Cave Nectar Bat	*Eonycteris spelaea glandifera*		+	+	LC	-
13	Philippine Pygmy Squirrel	*Exilisciurus concinnus*		+	+	LC	-
14	Fischer's Pygmy Fruit Bat	*Haplonycteris fischeri*		+	+	LC	-

No	Common Name	Scientific Name	LSBP 2021	Mal 2013	Ric 1993	Cons. Status	
						IUCN	DENR
15	Lesser Hairy-winged Bat	*Harpiocephalus harpia*			+	LC	-
16	Harpy Fruit Bat	*Harpyionycteris whiteheadi whiteheadi*		+	+	LC	-
17	Dark Leaf-nosed Bat	*Hipposideros ater*		+	+	LC	-
18	Dusky Leaf-nosed Bat	*Hipposideros bicolor*		+		LC	-
19	Diadern Leaf-nosed Bat	*Hipposideros diadema griseus*			+	LC	-
20	Philippine Forest Roundleaf Bat	*Hipposideros obscurus*			+	LC	-
21	Common Woolly Bat	*Kerivoula hardwickii*			+	LC	-
22	Long-tailed Macaque	*Macaca fascicularis philippinensis*	+	+	+	VU	-
23	Dagger-toothed Flower Bat	*Macroglossus minimus lagochilus*		+	+	LC	-
24	Lesser False Vampire Bat	*Megaderma spasma spasma*		+		LC	-
25	White-collared Fruit Bat	*Megaerops wetmorei*		+		VU	-
26	Lesser Bent-winged Bat	*Miniopterus australis paululus*			+	LC	-
27	Schreiber's Bent-winged Bat	*Miniopterus schreibersii eschscholtzii*			+	VU	-
28	Great Long-fingered Bat	*Miniopterus tristis*			+	LC	-
29	Round-eared Tube-nosed Bat	*Murina cyclotis*			+	LC	-
30	House Mouse	*Mus musculus castanaeus*			+	LC	-
31	Nepalese Whiskered Bat	*Myotis muricola browni*		+	+	LC	-
32	Common Palm Civet	*Paradoxurus hermaphroditus philippinensis*	+	+	+	LC	-
33	Short-winged Pipistrelle	*Philetor brachypterus*			+	LC	-
34	Greater Musky Fruit Bat	*Ptenochirus jagori*		+	+	LC	-
35	Lesser Musky Fruit Bat	*Ptenochirus minor*	+	+	+	LC	-
36	Island Flying Fox	*Pteropus hypomelanus cagayanus*		+	+	NT	-
37	Little Golden-mantled Flying Fox	*Pteropus pumilus*			+	NT	-
38	Giant Flying Fox	*Pteropus vampyrus lanensis*		+	+	NT	EN
39	Philippine Forest Rat	*Rattus everetti*		+	+	LC	-
40	Polynesian Rat	*Rattus exulans*			+	LC	-
41	House Rat	*Rattus rattus mindanensis*			+	LC	-
42	Oriental House Rat	*Rattus tanezumi*	+	+		LC	-
43	Arcuate Horseshoe Bat	*Rhinolophus arcuatus*		+	+	LC	-
44	Philippine Forest Horseshoe Bat	*Rhinolophus inops*		+	+	LC	-
45	Large-Eared Horseshoe Bat	*Rhinolophus philippinensis*		+		LC	-
46	Large Rufous Horseshoe Bat	*Rhinolophus rufus*			+	NT	-
47	Small Rufous Horseshoe Bat	*Rhinolophus subrufus*		+		DD	-
48	Lesser Woolly Horseshoe Bat	*Rhinolophus virgo*			+	LC	-
49	Geoffroy's Rousette Fruit Bat	*Rousettus amplexicaudatus*		+	+	LC	-
50	Philippine Brown Deer	*Rusa marianna* (a, b)	+	+	+	VU	EN
51	Lesser Asiatic Yellow House Bat	*Scotophilus kuhlii*			+	LC	-
52	Oriental House Shrew	*Suncus murinus occultidens*			+	LC	-
53	Samar Squirrel	*Sundasciuruss samarensis*			+	LC	-
54	Philippine Warty Pig	*Sus philippensis mindanensis* (a, b)	+	+	+	VU	VU
55	Tomb Bat	*Taphozous melanopogon philippinensis*			+	LC	-
56	Philippine Tarsier	*Tarsius syrichta* (a, c; A-II)	+	+	+	NT	OTS
57	Malay Civet	*Viverra tangalunga*		+	+	LC	-

Luzon Wart Frog
Fejervarya vittigera Wiegmann 1834

Puddle Frog
Occidozyga laevis Günther 1858

Cane Toad
Rhinella marina Linnaeus 1758

Common Green Frog
Hylarana erythraea Schlegel 1837

Common Tree Frog
Polypedates leucomystax Gravenhorst 1829

Maren’s Bronzeback
Dendrelaphis marenae Vogel & Van Rooijen 2008

Figure A1. Some of the herpetofauna species found in the LSBP.

Philippine Shrub Snake
Oxyrhabdium modestum
(Duméril, Bibron & Duméril 1854)

Tokay Gecko
Gekko gecko Linnaeus 1758

Indo-Pacific Tree Gecko
Hemiphyllodactylus typus Bleeker 1860

Green crested lizard
Bronchocela cristatella Kuhl, 1820

Samar Water Monitor
Varanus samarensis Koch, Gaulke & Böhme 2010

Common Mabuya
Eutropis multifasciata Kuhl 182

Figure A2. Additional herpetofauna species found in the LSBP.

Common Palm Civet
Paradoxurus hermaphroditus philippinensis
Jourdan 1837

Oriental House Rat
Rattus tanezumi Temminck 1845

Lesser Dog-faced Fruit Bat
Cynopterus luzoniensis Peters 1861

Lesser Musky Fruit Bat
Ptenochirus minor Yoshiyuki 1979

Figure A3. Mammal species found in the LSBP.