

# Fauna and Flora of Forests Over Limestone in Calicoan Island, Guiuan Marine Reserve Protected Landscape and Seascape (GMRPLS), Eastern Samar, Philippines

Desamarie Antonette P. Fernandez

(corresponding author)

Animal Biology Division, Institute of Biological Sciences, College of Arts and Sciences; CONserve KAIGANGAN Program, University of the Philippines Los Baños, College, Laguna, Philippines  
dpfernandez1@up.edu.ph

Marjorie D. delos Angeles

Plant Biology Division, Institute of Biological Sciences, College of Arts and Sciences; CONserve KAIGANGAN Program, University of the Philippines Los Baños, College, Laguna, Philippines  
Center of Integrative Conservation, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Mengla, Yunnan, China

Ren Divien R. Obeña

CONserve KAIGANGAN Program, Institute of Biological Sciences, University of the Philippines Los Baños, College, Laguna, Philippines

Paul John S. Tolentino

CONserve KAIGANGAN Program, Institute of Biological Sciences, University of the Philippines Los Baños, College, Laguna, Philippines

Elaine Loreen C. Villanueva

CONserve KAIGANGAN Program, Institute of Biological Sciences, University of the Philippines Los Baños, College, Laguna, Philippines

Inocencio E. Buot Jr.

Plant Biology Division, Institute of Biological Sciences, College of Arts and Sciences; CONserve KAIGANGAN Program, University of the Philippines Los Baños, College, Laguna, Philippines

## Publication Information:

Received 21 July 2020, Accepted 18 October 2020, Available online 22 December 2020  
DOI: 10.21463/jmic.2020.09.2.07

## Abstract

This study presents the first checklist of the lesser known terrestrial biodiversity in forests over limestone karst of Calicoan Island in Guiuan Marine Reserve Protected Landscape and Seascape, Guiuan, Eastern Samar, Philippines. Plants and terrestrial vertebrate species in nine 20x20 m plots and 18 line transects were recorded and identified. A total of 60 bird, eight reptile, one amphibian, and six mammal species were recorded. Moreover, a total of 41 floral species were documented belonging to 17 plant families and 24 genera. Of the plant species recorded, 5 were shrubs and 35 were trees. This study reported a new locality record of the Philippine endemic tree species *Hancea wenzeliana*, and new island records for fauna such as *Varanus samarensis* and *Cyrtodactylus sumuroi*, among many others. To date, the

present study is the only assessment of herpetofauna and mammals in Guiuan and represent new island records for most of these taxa in Calicoan Island. Among plants, *Shorea negrosensis*, *Aquilaria cumingiana* and *Wallaceodendron celebicum* were identified to have a vulnerable conservation status based on their IUCN Red List and DENR-DAO 2017-11. These native and endemic plants can be used for reforestation programs in the area, and conserving biodiversity in general will be crucial to potential ecotourism programs.

## Keywords

Guiuan, kaigangan, forest over limestone, biodiversity, ecotourism, resiliency

## Introduction

Forests over limestone are major foci for speciation and important biodiversity arks (Day & Urich, 2000) which contain unique biodiversity because of their unique topology. Biological diversity is a significant driver towards nature conservation (Myers et al., 2000) and is responsible for various ecosystem services which contribute to human well-being and survival, among others. Despite its high species endemism and environmental heterogeneity, forests over limestone are more vulnerable since they recover slower due to relatively dry habitat and shallow soil, which can be irreversible once damaged (Tuyet, 2001).

Guiuan Marine Reserve Protected Landscape and Seascape (GMRPLS) in Eastern Samar, Philippines was designated as a protected area by virtue of Presidential Proclamation No. 469 in 1994. It is notable for its rich marine resources which are utilized by local residents, the academe and surfers. It may be rich in terrestrial and marine resources, but most research conducted in the area were focused on marine plants and algae (Peja et al., 2018; Corales-Ulta et al., 2019), mangrove communities along the coastline of Eastern Samar (Mendoza and Alura, 2001; Alura and Alura, 2016), and assessment of household resiliency (Hilvano et al., 2016) after Typhoon Haiyan (local name Yolanda). This typhoon was a fast-moving and extremely intense tropical cyclone which devastated the island in the year 2013 (Lin et al., 2014; Takagi and Esteban, 2016).

Most of the terrestrial forest areas of this protected area remain largely unexplored and biological knowledge is deficient. There are currently no published studies with emphasis on the terrestrial biodiversity of the forests over limestone of GMRPLS. Additional efforts for biodiversity documentation and forest ecosystem monitoring of the area will be a way to address the gaps. Thus, there is a need for collections and updates of faunal and floristic inventories. These are important especially in areas such as forest over limestone which require proper conservation, monitoring, and management. Knowledge in terrestrial biodiversity can lead to proper management practices to protect these forests from threats, abusive land use patterns (Sodhi et al., 2010), alterations, and climate change which would be of great help, specifically for GMRPLS, given that its geographic position that faces the Pacific Ocean making the entire protected area prone to typhoons, storm surges and tsunamis.

This study aimed to evaluate the faunal and floral composition of forests over limestone in GMRPLS with notes on conservation and distribution, and to discuss the value of terrestrial biodiversity to resilience and ecotourism. The study will provide biological reference in the form of a checklist for future ecological research, conservation, and monitoring efforts.

## Materials and Methods

### Study area

Guiuan Marine Reserve Protected Landscape and Seascape (GMRPLS) can be found in the southeastern tip of Samar Island facing the Pacific Ocean (Fig. 1). It is located in the municipality of Guiuan, in the province of Eastern Samar, Philippines, approximately 10°58'57.1"N latitude and 125°48'10.9"E longitude. It has a total area of 60,448 hectares covering the coastal areas of Guiuan and nearby islands of Calicoan, Manicani, Candulo, Suluan, Tubabao, and Homonhon and surrounding reefs.

The selection of sampling plots was based on the biophysical characteristics of the area including plant diversity heterogeneity, topographic attribute (elevation), extent of forest over limestone area, and presence of anthropogenic disturbances. An assessment of the faunal and floral diversity of GMRPLS was conducted on October 8–11, 2019, as part of Project 1: Assessment of Biodiversity in Forest Over Limestone Ecosystem. This is a component of the government-funded research program, Assessment and Conservation of Forest Over Limestone Ecosystem Biodiversity in Selected Municipalities of Samar, Philippines (CONserve-KAIGANGAN). Since Calicoan Island has the largest continuous forest over limestone area in GMRPLS, nine 20x20 m vegetation plots were deployed across its four barangays (abbreviated as brgy., the Filipino term for a district): Baras, Ngolos, Pagnamitan and Sulangan.

### Faunal diversity assessment

Various methods adopted from the Manual on Biodiversity Assessment and Monitoring System for Terrestrial Ecosystems (Cruz et al., 2017) were used to assess terrestrial vertebrate diversity within the established plots and transects. Herpetofauna, which includes amphibians and reptiles, were hand-captured within the sampling plots or collected using forceps, snake hook/tongs and placed in separate labeled resealable plastic bags for easier identification. All individuals were immediately released after species identification.

A simple line transect count was done for the survey of birds. Binoculars, field guides such as those by Kennedy et al. (2000) and Arlott (2018), as well as online references such as Handbook of the Birds of the World Alive (del Hoyo et al., 2020), were used to aid in species identification. Birds were photographed using DSLR camera with telephoto lens and a digital audio-recorder was used for recording bird calls.

To capture birds and volant mammals, 12-meter mist nets were set along possible flyways and feeding trees in or around the sampling plots. These are nylon nets with 35 mm sized mesh, set in 3–4 rungs with loose pockets to allow capture. Mist nets were checked periodically for possible netted individuals every hour from 1830 to 2200 h. Nets are opened for 24 hours for at least three days and two nights. Each captured animal was carefully removed from the net and placed individually in cloth bags to minimize stress and injury. All individuals were immediately released after species identification.

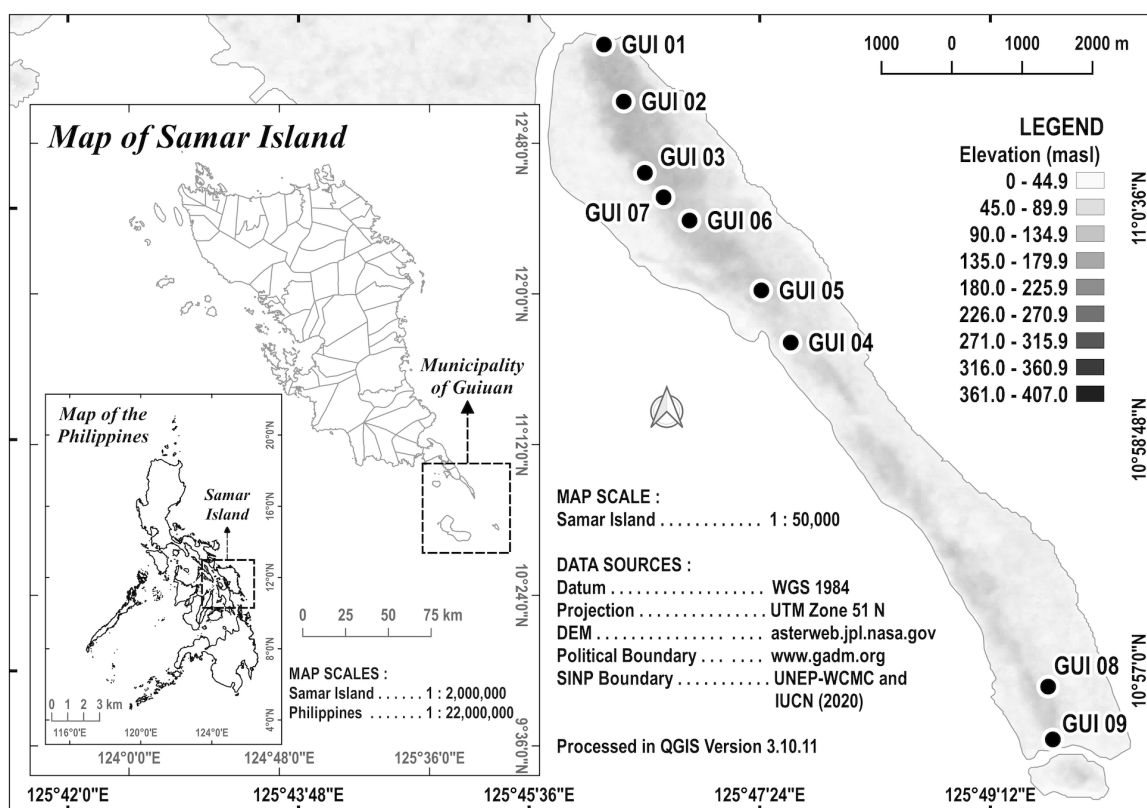


Fig 1. Map of Guiuan Marine Reserve Protected Landscape and Seascape (GMRPLS), Philippines. Established plots are marked in black circles.

Steel mesh cage traps were used to capture small non-volant mammals. To prepare bait, thinly sliced coconut meat was fried until brown and coated generously with peanut butter. Live earthworms also served as bait when available. Rat traps were set within sampling plots and along transects. For trapping on the ground surface, the traps were positioned 5–10 m apart under root tangles, in front of burrow entrances, along runways, and beside or on top of fallen logs. For aboveground trapping, the traps were tied onto horizontal branches of trees. Captures were retrieved early in the morning (c. a. 0700 h) and baits were replaced in the late afternoon (c.a. 1700 h). All individuals were immediately released after species identification. Camera traps were also set up to photograph large or cryptic species.

## Floral diversity assessment

Two types of methods were used to determine the plant species composition of each sampling site. The quadrat or plot technique was used to assess the trees ( $\geq 1$  m), while line intercept technique was used for understory plant species. Trees and shrubs inside each plot were recorded. Coordinates and elevation of sampling plots were taken using the Garmin Montana 680 Global Positioning System (GPS). A total of 9 plots and 18 line transects were established in Guiuan to assess trees and the understory species, respectively. Two line transects, 5 m in length and subdivided with 1 m intervals, were deployed inside each sampling plot. The local name, height, and cover of all plant species transverse in the line were recorded per 1 m interval markings.

## Herbarium specimen

Voucher specimens were collected for proper identification and documentation. These were then processed, and herbarium specimens were deposited in the Plant Biology Division Herbarium (PBDH), Institute of Biological Sciences, University of the Philippines Los Baños. Specimens were identified utilizing original descriptions, taxonomic revisions, and botanical keys. Our specimens were also compared with the collections of PBDH and from available online resources such as “Co’s Digital Flora of the Philippines” (Pelser et al., 2011). Because existing databases and updated information regarding the flora of Samar are wanting, experts from the Philippine National Museum were consulted in order to identify the unknown plant specimens. Voucher information for the specimens, geographic coordinates of collection sites, life form, and endemism were also noted. Nomenclature follows that of Pelser et al. (2011).

## Secondary data collection

Published literature, monographs, and other checklists regarding biodiversity in Guian were also reviewed in relation to species occurrence and endemism. The endemic status of each species was verified by consulting available checklists, related publications, and online resources.

The conservation status of each animal species was determined from the International Union for the Conservation of Nature (IUCN) Red List and the Department of Environment and Natural Resources Administrative Order (DAO) 2019-09 or the Updated National List of Threatened Philippine Fauna and Their Categories (DENR, 2019). Meanwhile, the IUCN Red List conservation status of each plant species was determined from “Co’s Digital Flora of the Philippines” (Pelser et al., 2011) and the DAO 2017-11 or the Updated National List of Threatened Philippine Plants and Their Categories (DENR, 2017).

## Results

### Faunal composition of tropical forest over limestone

A total of one amphibian, eight reptile, 60 bird, and six mammal species were recorded during the fieldwork (Table 1). The only amphibian species found, *Platymantis guentheri*, is endemic to the Mindanao Pleistocene Aggregate Island Complex (PAIC). Four of the reptile species, *Draco bimaculatus*, *Sphenomorphus jabori*, *Cyrtodactylus sumuroi*, and *Varanus samarensis*, are Philippine endemics, the last two of which are Mindanao PAIC endemics. Eleven bird species are known to be migratory species, and two species, *Phylloscopus olivaceus* and *Hypsipetes philippinus saturator*, are Philippine endemics, the latter of which is a Mindanao PAIC endemic subspecies. Two of the volant mammal species, *Ptenochirus jabori* and *Ptenochirus minor*, are Philippine endemics, the latter of which is a Mindanao PAIC endemic. The two non-volant mammal species, *Rattus everetti* and *Bullimus bagobus*, are Philippine endemics, the latter of which is a Mindanao PAIC endemic.

Among these bird species, only 6 were documented during the field assessment. The majority of avian records in this checklist were from secondary sources such as Potter (1953) and Canillas (2018a, 2018b, 2019). Although Potter

documented the presence of the critically endangered *Cacatua haematurypygia* in 1953, they may now be extinct in the region (BirdLife International, 2017), although further study is required to verify this information.

Table 1. List of terrestrial vertebrate species recorded from the forests over limestone of Guiuan Marine Reserve Protected Landscape and Seascape in Guiuan, Eastern Samar, Philippines.

Order	Family	Species	Common Name	Distribution	Conservation Status*		Reference
					IUCN Red List	DAO 2019-09	
Amphibians							
Anura	Ceratobatrachidae	<i>Platymantis guentheri</i>	Gunther's wrinkled ground frog	Endemic	LC	None	Fieldwork
Reptiles							
Squamata	Agamidae	<i>Bronchocela cristatella</i>	Green crested lizard	Resident	None	OTS	Fieldwork
		<i>Draco bimaculatus</i>	Two-spotted flying lizard	Endemic	LC	None	Fieldwork
	Scincidae	<i>Lamprolepis smaragdina philippinica</i>	Emerald tree skink	Resident	None	None	Fieldwork
		<i>Sphenomorphus jagori</i>	Jagor's sphenomorphus	Endemic	LC	None	Fieldwork
	Gekkonidae	<i>Cyrtodactylus sumuroi</i>	Samar bent-toed gecko	Endemic	None	None	Fieldwork
	Pythonidae	<i>Malayopython reticulatus</i>	Reticulated python	Resident	LC	OTS	Fieldwork
	Viperidae	<i>Tropidolaemus subannulatus</i>	Keeled Green Pit Viper	Resident	LC	OTS	Fieldwork
	Varanidae	<i>Varanus samarensis</i>	Samar water monitor	Endemic	None	OTS	Fieldwork
Birds							
Pelecaniformes	Ardeidae	<i>Ardea intermedia</i>	Intermediate egret	Migratory	LC	None	Canillas 2018a
		<i>Butorides striata</i>	Green-backed heron	Migratory	LC	None	Potter 1953
		<i>Egretta sacra</i>	Pacific reef heron	Resident	LC	None	Potter 1953
		<i>Nycticorax caledonicus</i>	Rufous night heron	Resident	LC	None	Canillas 2019
Accipitriformes	Accipitridae	<i>Haliastur indus</i>	Braminy kite	Resident	LC	None	Potter 1953
		<i>Accipiter trivirgatus</i>	Crested goshawk	Resident	LC	None	Potter 1953
		<i>Spilornis holospilus</i>	Philippine serpent eagle	Endemic	LC	None	Potter 1953
	Falconidae	<i>Microhierax erythrogenys</i>	Philippine falconet	Endemic	LC	None	Potter 1953
Charadriiformes	Charadriidae	<i>Charadrius mongolus</i>	Lesser sand plover	Migratory	LC	None	Canillas 2018a
		<i>Pluvialis fulva</i>	Pacific golden plover	Migratory	LC	None	Potter 1953
	Scolopacidae	<i>Calidris minuta</i>	Little stint	Resident	LC	None	Potter 1953
		<i>Limosa lapponica</i>	Bar-tailed godwit	Migratory	NT	None	Canillas 2018b
		<i>Numenius madagascariensis</i>	Far Eastern curlew	Migratory	EN	None	Canillas 2018b
		<i>Numenius phaeopus</i>	Eurasian whimbrel	Migratory	LC	None	Potter 1953
		<i>Tringa brevipes</i>	Grey-tailed tattler	Migratory	NT	None	Potter 1953
		<i>Tringa totanus</i>	Common redshank	Migratory	LC	None	Canillas 2019
		<i>Phalaropus lobatus</i>	Red-necked phalarope	Migratory	LC	None	Potter 1953

Order	Family	Species	Common Name	Distribution	Conservation Status*		Reference
					IUCN Red List	DAO 2019-09	
Columbiformes	Columbidae	<i>Phapitreron brevirostris brevirostris</i>	Short-billed brown-dove	Endemic	LC	None	Potter 1953
		<i>Ducula aenea</i>	Green imperial-pigeon	Resident	LC	None	Potter 1953
Cuculiformes	Cuculidae	<i>Cuculus saturatus</i>	Oriental cuckoo	Resident	LC	None	Potter 1953
		<i>Cuculus canorus</i>	Common cuckoo	Migratory	LC	None	Potter 1953
		<i>Eudynamis scolopaceus</i>	Western koel	Resident	LC	None	Potter 1953
		<i>Centropus viridis viridis</i>	Philippine Coucal	Endemic	LC	None	Potter 1953
Coraciiformes	Alcedinidae	<i>Alcedo atthis bengalensis</i>	Common kingfisher	Resident	LC	None	Potter 1953
		<i>Halcyon coromanda</i>	Ruddy kingfisher	Migratory	LC	None	Fieldwork
		<i>Todiramphus winchelli nigrorum</i>	Rufous-lored kingfisher	Endemic	VU	VU	Potter 1953
		<i>Todiramphus chloris</i>	Collared kingfisher	Resident	LC	None	Potter 1953
	Coraciidae	<i>Eurystomus orientalis</i>	Oriental dollarbird	Resident	LC	None	Potter 1953
	Meropidae	<i>Merops philippinus</i>	Blue-tailed bee-eater	Resident	LC	None	Potter 1953
Bucerotiformes	Bucerotidae	<i>Buceros mindanensis semigaleatus</i>	Southern rufous hornbill	Endemic	VU	EN	Potter 1953
		<i>Penelopides affinis</i>	Mindanao hornbill	Endemic	LC	EN	Potter 1953
Piciformes	Picidae	<i>Picoides maculatus fulvifasciatus</i>	Philippine pygmy woodpecker	Endemic	LC	None	Potter 1953
		<i>Chrysocolaptes lucidus rufopunctatus</i>	Buff-spotted flameback	Endemic	LC	None	Potter 1953
		<i>Dryocopus javensis pectoralis</i>	White-bellied woodpecker	Resident	LC	None	Potter 1953
Psittaciformes	Cacatuidae	<i>Cacatua haematuropygia</i>	Philippine cockatoo	Endemic	CR	CR	Potter 1953
	Psittacidae	<i>Loriculus philippensis</i>	Colasisi	Endemic	LC	CR	Potter 1953
		<i>Prioniturus discurus whiteheadi</i>	Blue-crowned racket-tail	Endemic	LC	OTS	Potter 1953
Passeriformes	Artamidae	<i>Artamus leucorhynchus leucorhynchus</i>	White-breasted woodswallow	Resident	LC	None	Potter 1953
	Campephagidae	<i>Coracina striata boholensis</i>	Bar-bellied cuckooshrike	Resident	LC	None	Potter 1953
	Cisticolidae	<i>Orthotomus frontalis frontalis</i>	Rufous-fronted tailorbird	Endemic	LC	None	Potter 1953
	Corvidae	<i>Corvus macrorhynchos</i>	Large-billed crow	Resident	LC	OTS	Potter 1953
	Dicaeidae	<i>Dicaeum papuense papuense</i>	Philippine Flowerpecker	Resident	LC	None	Potter 1953
		<i>Dicaeum trigonostigma cinereigulare</i>	Grey-throated flowerpecker	Resident	LC	None	Potter 1953
	Dicruridae	<i>Dicrurus striatus</i>	Short-tailed drongo	Endemic	LC	None	Potter 1953
	Laniidae	<i>Lanius cristatus lucionensis</i>	Brown shrike	Resident	LC	None	Fieldwork, Potter 1953
	Hirundinidae	<i>Hirundo javanica</i>	House swallow	Resident	LC	None	Potter 1953
	Motacillidae	<i>Anthus gustavi</i>	Pechora pipit	Migratory	LC	None	Potter 1953
		<i>Motacilla tschutschensis</i>	Eastern yellow wagtail	Resident	LC	None	Potter 1953



Order	Family	Species	Common Name	Distribution	Conservation Status*		Reference
					IUCN Red List	DAO 2019-09	
	Muscicapidae	<i>Cyornis rufigastra philippinensis</i>	Mangrove blue-flycatcher	Resident	LC	None	Fieldwork
		<i>Monticola solitarius philippensis</i>	Eastern blue rock-thrush	Resident	LC	None	Fieldwork, Potter 1953
		<i>Muscicapa griseisticta</i>	Gray-streaked flycatcher	Resident	LC	None	Potter 1953
	Nectariniidae	<i>Leptocoma sperata trochilus</i>	Purple-throated sunbird	Endemic	LC	None	Potter 1953
	Oriolidae	<i>Oriolus chinensis</i>	Black-naped oriole	Resident	LC	None	Potter 1953
	Phylloscopidae	<i>Phylloscopus borealis</i>	Arctic warbler	Resident	LC	None	Potter 1953
		<i>Phylloscopus olivaceus</i>	Philippine leaf-warbler	Endemic	LC	None	Fieldwork
	Pycnonotidae	<i>Hypsipetes philippinus saturator</i>	Philippine bulbul	Endemic	LC	None	Fieldwork, Potter 1953
	Sturnidae	<i>Aplonis panayensis</i>	Asian glossy starling	Resident	LC	None	Potter 1953
		<i>Sarcops calvus</i>	Coletto	Endemic	LC	None	Potter 1953
		<i>Rhabdornis mystacalis minor</i>	Stripe-headed rhabdornis	Endemic	LC	None	Potter 1953
	Zosteropidae	<i>Zosterops palpebrosus basilanica</i>	Oriental White-eye	Resident	LC	None	Potter 1953
Mammals							
Chiroptera	Pteropodidae	<i>Ptenochirus jagori</i>	Greater musky fruit bat	Endemic	LC	None	Fieldwork
		<i>Ptenochirus minor</i>	Lesser musky fruit bat	Endemic	LC	None	Fieldwork
		<i>Rousettus amplexicaudatus</i>	Geoffrey's rousette	Resident	LC	None	Fieldwork
Primates	Cercopithecidae	<i>Macaca fascicularis</i>	Long-tailed macaque	Resident	LC	None	Fieldwork
Rodentia	Muridae	<i>Rattus everetti</i>	Philippine forest rat	Endemic	LC	None	Fieldwork
		<i>Bullimus bagobus</i>	Bagobo rat	Endemic	LC	None	Fieldwork, Johnson 1946

\*CR- Critically Endangered, EN- Endangered, VU- Vulnerable, NT- Near Threatened, LC- Least Concern, OTS- Other Threatened Species, DD- Data Deficient

## Floral Composition of tropical forest over limestone

A total of 41 floral species were recorded belonging to 18 plant families and 24 genera (Table 2). The most represented family was Moraceae (5 spp.), followed by Arecaceae (3 spp.), Sapotaceae (2 spp.), Euphorbiaceae (2 spp.), Araceae (2 spp.), Thymelaeaceae (2 spp.), and Apocynaceae (2 spp.). Family Lomariopsidaceae, Aspleniaceae, Gnetaceae, Annonaceae, Commelinaceae, Fabaceae, Phyllanthaceae, Dipterocarpaceae, Malvaceae, and Cornaceae were each represented by a single species. Of the 41 floral species recorded, 6 are shrubs and 35 are trees.



Table 2. List of plant species recorded from the forests over limestone of Guiuan Marine Reserve Protected Landscape and Seascape in Guiuan, Eastern Samar, Philippines.

Plant Group Family	Scientific Name	Common Name	Exsiccata	Habit	Conservation Status		
					IUCN Red List	DAO 2017-11	Endemicity
Pteridophyta							
Lomariopsidaceae	<i>Cyclopeltis crenata</i> (Fée) C. Chr.	Lukdo	Obeña 7111 (PBDH)	S	-	-	N
Aspleniaceae	<i>Asplenium vittaeforme</i> Cav.	Lorog	Obeña 7091 (PBDH)	S	-	NE	N
Spermatophyta: Gymnospermae							
Gnetaceae	<i>Gnetum gnemon</i> L.	Bago	Obeña 7073 (PBDH)	T	LC	NE	N
Spermatophyta: Angiospermae							
Annonaceae	<i>Monoon oblongifolium</i> (C.B.Rob.) B.Xue & R.M.K.Saunders	Lapisan	Obeña 7164 (PBDH)	T	-	NE	E
Araceae	<i>Aglaonema commutatum</i> Schott	Pilako	Obeña 7089 (PBDH)	S	-	-	N
	<i>Rhaphidophora</i> sp.	No common name	Obeña 7090 (PBDH)	S	-	NE	-
Pandanaceae	Unidentified	Bariw		S	-	-	-
Arecaceae	<i>Saribus rotundifolius</i> (Lam.) Blume	Anahaw	Obeña 7040 (PBDH)	T	-	NE	N
	<i>Heterospatha intermedia</i> (Becc.) Fernando	Banga	Obeña 7076 (PBDH)	T	-	NE	E
	<i>Caryota rumphiana</i> Mart.	Pugahan/ Tagabunga	Obeña 7087 (PBDH)	T	LC	NE	N
Commelinaceae	<i>Tradescantia zebrina</i> var. <i>zebrina</i> Synonym: <i>Zebrina pendula</i>	No common name	Obeña 7092 (PBDH)	S	-	NE	N
Euphorbiaceae	<i>Hancea wenzeliana</i> (Slik) S.E.C.Sierra, Kulju & Welzen	Apanang	Obeña 7072 (PBDH)	T	-	NE	E
	<i>Macaranga tanarius</i> (L.) Müll.Arg.	Minunga	Obeña 7085 (PBDH)	T	-	NE	N
Phyllanthaceae	<i>Bridelia glauca</i> Blume	Anislag	Obeña 7102 (PBDH)	T	-	NE	N
Fabaceae	<i>Wallaceodendron celebicum</i> Koord.	Banuyo/ Salukigi	Obeña 7077 (PBDH)	T	-	VU	N
Moraceae	<i>Artocarpus blancoi</i> (Elmer) Merr.	Antipolo	-	T	-	NE	E
	<i>Artocarpus rubrovenius</i> Warb.	Tugop	Obeña 7147 (PBDH)	T	OTS	NE	E
	<i>Ficus ampelas</i> Burm.f.	Lanete	Obeña 7084 (PBDH)	T	LC	NE	N
	<i>Ficus</i> sp. (2)	Hagimit	Obeña 7082 (PBDH)	T	-	NE	-
	<i>Ficus</i> sp. (1)	Dalakit	Obeña 7079 (PBDH)	T	-	NE	-
Thymelaeaceae	<i>Aquilaria cumingiana</i> (Decne.) Ridl.	Agar/ Lapnisan	Obeña 7070 (PBDH)	T	VU	VU	N
	<i>Gonystylus reticulatus</i> (Elmer) Merr.	Batuan	-	T	-	NE	-

Plant Group Family	Scientific Name	Common Name	Exsiccata	Habit	Conservation Status		
					IUCN Red List	DAO 2017-11	Endemicity
Dipterocarpaceae	<i>Shorea negrosensis</i> Foxw.	Lawaan na Pula (Takuban)	Obeña 7122 (PBDH)	T	LC	VU	E
Malvaceae	<i>Sterculia comosa</i> Wall.	Balinad	-	T	-	NE	-
Cornaceae	<i>Mastixia</i> sp.	Tul-anan	Obeña 7148 (PBDH)	T	-	NE	-
Sapotaceae	<i>Palaquium</i> sp. (1)	Bagotambis	Obeña 7074 (PBDH)	T	-	NE	-
	<i>Palaquium</i> sp. (2)	Nato	Obeña 7086 (PBDH)	T	-	NE	-
Apocynaceae	<i>Wrightia</i> sp.	Hamor-awon	Obeña 7083 (PBDH)	T	-	NE	-
	<i>Alstonia scholaris</i> (L.) R. Br.	Dita	Obeña 7081 (PBDH)	T	LC	NE	N
Unidentified species							
	Unidentified	Yakal	Obeña 7151 (PBDH)	T	-	-	-
	Unidentified	Bago-eho	Obeña 7095 (PBDH)	T	-	-	-
	Unidentified	Bagubahi	Obeña 7075 (PBDH)	T	-	-	-
	Unidentified	Bayarong	Obeña 7078 (PBDH)	T	-	-	-
	Unidentified	Dalunutan	Obeña 7080 (PBDH)	T	-	-	-
	Unidentified	Amahoyan	-	T	-	-	-
	Unidentified	Atipon	-	T	-	-	-
	Unidentified	Bagnaw	-	T	-	-	-
	Unidentified	Kuyakya	-	T	-	-	-
	Unidentified	Lubi	-	T	-	-	-
	Unidentified	Pamintaogon	Obeña 7128 (PBDH)	T	-	-	-
	Unidentified	Hambabalud	Obeña 7045 (PBDH)	T	-	-	-

\*Vouchers, habit (T = tree, S = shrub, H = herb), Status based IUCN Red List of Threatened Species or DAO 2017-11 (NE = Not Evaluated, DD = Data deficient, OT = Other Threatened Species, LC = Least Concern, VU = Vulnerable, EN = Endangered, CR = Critically endangered), endemicity (E = Philippine endemic, N = non-endemic). Sensu APG IV (2016).

## Discussion

### Terrestrial vertebrate diversity

The present study is the only assessment of amphibians, reptiles, and mammals in Guiuan, and represent new island records for most of these taxa in Calicoan Island. The only other published assessment of fauna in GMRPLS is a survey of birds in Calicoan Island by Potter (1953) which recorded 51 species also listed in Table 1 with updated taxonomy. Among all the faunal species found and recorded, the following are notable for their uses, distribution, conservation and more.

### Notable animal species

#### *Platymantis guentheri* (Boulenger 1882)

Gunther's wrinkled ground frog (Fig. 2A) is a widespread endemic species in the Mindanao PAIC known from Biliran, Bohol, Dinagat, Samar, Leyte and Mindanao (Diesmos et al., 2015). Nine adult individuals were hand-captured near Linao Cave in Brgy. Sulangan, a new record for Calicoan Island. The species is highly abundant and capable of thriving in second growth, degraded, and fragmented patches of habitat (Sanguila et al., 2016). Some of the species were caught from fallen logs but most of them were observed perching on karst substrates, then quickly jumping into the limestone crevices to escape once disturbed. The species is currently listed as Least Concern in the IUCN, but it is an important indicator of the health of the karst ecosystem since they are sensitive to environmental changes.

#### *Cyrtodactylus sumuroi* Welton et al. 2010

The first records of the Samar bent-toed gecko (Fig. 2B) were from the forests of Brgy. San Rafael, Taft, Samar Island (Welton et al., 2010), and this study presents a new island record for the species in Calicoan Island. One adult individual was hand-captured near Linao Cave in Brgy. Sulangan, while three individuals hiding in limestone crevices were captured in Brgy. Pagnamitan (Fig. 2C). It is not yet assessed in the IUCN Red List and DAO 2019-09 and may require further study to assess its conservation status.

#### *Varanus samarensis* Koch et al. 2010

The Samar water monitor was previously known only from Samar, Leyte and Bohol Islands (Welton et al. 2014), and this study presents a new island record for the species in Calicoan Island. An adult individual was seen in Brgy. Pagnamitan. Information about the ecology of this species is still lacking (Koch et al. 2010), and it is categorized as Other Threatened Species (OTS) under the DAO 2019-09.

#### *Hypsipetes philippinus saturator* (E. J. O. Hartert, 1916)

The Philippine bulbul (Fig. 2D) is a Philippine endemic bird characterized by dominant olive brown plumage with a streaked rufous throat. Five subspecies are currently recognized in the Philippines (del Hoyo et al., 2020) categorized according to differences in color shade, boldness of shaft streaks on throat, and small differences in overall size

(Kennedy et al., 2000). The subspecies *H. philippinus saturator* can be found in east central and southern Philippines. An adult individual was netted in Brgy. Pagnamitan.

#### *Ptenochirus minor*

The lesser musky fruit bat (Fig. 2E) is dark in coloration with short, sturdy snouts that is endemic in the Mindanao PAIC. In Brgy. Pagnamitan, three male adult individuals and two male subadult individuals were netted. This species can easily be mistaken for *Ptenochirus jagori* but can be distinguished by their difference in forearm lengths. *P. minor* has a forearm length of 60–78 mm while *P. jagori* has 76–90 mm (Ingle and Heaney, 1992).

#### *Bullimus bagobus*

The Bagobo rat (Fig. 2F) is a large murid species widespread in the Mindanao PAIC. A male subadult individual was trapped in Brgy. Sulangan near Linao Cave. It can be differentiated from *Rattus everetti* by having a tail that is notably shorter than the combined length of the head and body, with a longer and moderately wide hind feet (Rickart et al., 2002).



Fig 2. Some of the notable terrestrial vertebrate species from the forests over limestone of Guiuan Marine Reserve Protected Landscape and Seascape in Guiuan, Eastern Samar, Philippines: A) *Platymantis guentheri*, B & C) *Cyrtodactylus sumuroi*, D) *Hypsipetes philippinus saturator*, E) *Ptenochirus minor*, and F) *Bullimus bagobus*.

## Plant diversity

Species richness of tropical forests in Southeast Asia can range from 60 to 250 species per hectare (Losos and Leigh, 2004). The species richness of the tropical forest over limestone of Guiuan is below the aforementioned range. Generally, the forest is young, dominated by saplings and small diameter-sized trees. This could be attributed to the possibility that the forest over limestone in Guiuan is still recovering from the heavy rains and destructive winds of typhoon Haiyan which hit the island in 2013.

It was also observed that the area has low species richness as compared to other forest over limestones. Samar Island Natural Park (SINP) was recorded to have 212 timber species in the twenty-five 20x20 m plots (Quimio, 2016). In a similar study, 288 vascular plants were inventoried across the northeastern side of Mt. Tabunan, Cebu Island (Cadiz and Buot, 2010). In a study conducted by Lillo et al. (2019b), a total of 112 tree species were recorded from four 20x100-m permanent plots in Mount Lantoy key biodiversity areas in Argao, Cebu, Philippines. In Dinagat Island, a total of 432 native plant species were recorded across six different forest habitat types in which 58% were recorded from lowland evergreen forest, 16% from upper montane, 15% in forest over limestone, 6% in lower montane forest, 4% in mangrove forest, and 1% in beach forest (Lillo et al., 2019a). In a study conducted by Adam and Mamat (2005), they recorded a total of 1682 trees in a 0.75 ha plot. In the tropical forest over limestone in Xishuangbanna, China, a total of 100 tree species belonging to 74 genera and 31 families were recorded in the four 0.25 ha plots (Tang et al., 2011). Based from literature and comparisons, it would seem that floral species diversity in tropical forests over limestone varies greatly across different areas. The following is a short list of notable species of plant life found in the area.

## Notable plant life

### *Hancea wenzeliana* (Slik) S.E.C. Sierra, Kulju & Welzen

This study reports a new locality record of this Philippine endemic tree species (Fig. 3). Based on literature, its native range is the island of Mindanao, Philippines. The occurrence of this tree species in Guiuan is not surprising since Samar is a constituent of greater Mindanao. Thus, this tree species seems to have a widespread distribution.



Fig 3. Vegetative structures of *Hancea wenzeliana* (Slik) S.E.C. Sierra, Kulju & Welzen collected from the forests over limestone of Guiuan Marine Reserve Protected Landscape and Seascape in Guiuan, Eastern Samar, Philippines.



*Aquilaria cumingiana* (Decne.) Ridl.

Commonly known as agarwood (Fig. 4), it is recorded as a well-known and important endemic tree species found in the Philippines and Indonesia. It is highly prized for its fragrant resin and utilized for various economic gains. Due to overharvesting leading to the rapid decline of its natural population, it is categorized as Vulnerable based on the DAO 2017-11 and the IUCN Red List. It is also protected under the Convention of International Trade in Endangered Species of Wild Flora and Fauna (CITES, 2004) regulation (Lee and Mohamed, 2016).

*Wallaceodendron celebicum* Koord.: Foxw. - in Philipp. J. Sc., Bot. 1907: 376; Koord., Suppl. Fl. Celebes. 1918: t. 1a, b.; Gilg - in E. & P., Nat. Pflanzenfam. 1900: 30

This species is recorded to occur in two Asian-Tropical countries, which are the Philippines and Indonesia. It is identified as Vulnerable based on the DAO 2017-11.



Fig 4. Vegetative and reproductive structures of *Aquilaria cumingiana* (Decne.) Ridl. collected from the forests over limestone of Guiuan Marine Reserve Protected Landscape and Seascape in Guiuan, Eastern Samar, Philippines. A) leaves and ripe fruits B) close up of the capsule.

## Conservation status of biodiversity in GMRPLS

The present study shows that the forests over limestone in GMRPLS are home to numerous threatened species, highlighting the significance of the protected area for the conservation of these animals and plants. In both taxa, there are some discrepancies between their conservation statuses based on the IUCN Red List and the updated Philippine national Red Lists, DAO 2017-11 and 2019-09. In many cases, species listed as Least Concern in the IUCN Red List have no conservation status in the national Red List. This is because the lowest category in the Philippine Red List for fauna is OTS, which is more similar in description to the Near Threatened category of the IUCN Red List (Gonzalez et al, 2018).

For the Samar water monitor, *V. samarensis*, it has not yet been assigned a conservation status by the IUCN perhaps because it was described only relatively recently by Koch et al. in 2010. However, this lizard is categorized in the Philippine Red List as OTS due to threats that include hunting for bushmeat and trade (BCSP, 2020). In some instances, the national conservation status may be higher than that of the IUCN status. Such is the case for the red lauau, *Shorea negrosensis* Foxw., and the reticulated python, *Malayopython reticulatus* Schneider 1801. For the former, more recent data used in the international assessment found that, though the population of this tree species may be in decline, it has a large enough extent of occurrence warranting a lower category (EDC, 2020). For the latter, it might be the opposite. The threat to this snake is lower internationally, but in the Philippines, it is highly persecuted or collected for trade (BCSP, 2020). This underscores the value of biodiversity monitoring to continuously update data that can serve as the basis for the formulation of environmental policies and protected area management strategies.

## Protected area management recommendations

The native fauna of GMRPLS, particularly birds, have a great economic value in terms of ecotourism. Taylor et al. (2015) described the Eastern Visayas Region to be “deserving more attention from birdwatchers and ornithologists”, therefore, stricter implementation of anti-poaching regulations should be upheld in GMRPLS. In a tourism development plan for Calicoan Island, Anore et al. (2019) proposed a community-based tourism approach. The region has been dubbed the surfing capital of Visayas and various surfing competitions plans may encourage more tourists which is related to the development of the area. It is recommended that sustainable ecotourism should be integrated into this approach, and the results of this present study could help inform local stakeholders on the status of the biodiversity and why conservation would be directly beneficial to ecotourism.

Integrating native and endemic tree species leads to species richness in natural tropical forests, and this should be incorporated into reforestation and plantation schemes for its conservation (Peque and Hölscher, 2014). It is recommended that propagation and reforestation efforts should be heightened especially but not limited to native and endemic tree species in Guiuan such as *A. cuminigiana*, *W. celebicum*, *H. wenzeliana*, *S. negrosensis*, *Artocarpus blancoi* (Elmer) Merr., *Artocarpus rubrovenius* Warb., and *Monoon oblongifolium* (C.B.Rob.) B.Xue & R.M.K.Saunders. These efforts will benefit forests heavily affected by Typhoon Haiyan.

According to literature, other plant species recorded from the site have several uses, such as alternative food sources from the leaves of *Gnetum gnemon* L. Table 3 shows other uses of select plant species from GMRPLS. These plants may also be propagated in the area for the benefit of the local community.



Table 3. Uses of select plant species recorded from the forests over limestone of Guiuan Marine Reserve Protected Landscape and Seascape in Guiuan, Eastern Samar, Philippines.

Plant Group	Family	Scientific Name	Plant Part	Uses	Reference
Gymnosperm	Gentaceae	<i>Gentum gnemon</i>	Leaves	Blanched and braised in small bamboo pots	Verheij and Sukendar (1991)
Angiosperm	Araceae	<i>Aglaonema commutatum</i>	Leaves	Potential for use as natural antimicrobial agents	Opryshko et al. (2019)
	Arecaceae	<i>Caryota rumphiana</i>	Whole plant	Ornamental	Di Benedetto (2006)
	Commelinaceae	<i>Tradescantia zebrina</i> var. <i>zebrina</i>	Leaves	Treat skin conditions, common colds, and has inhibitory effects on cancerous and non-cancerous cells	Moehring (2013)
	Thymelaeaceae	<i>Aquilaria cuminigiana</i>	Leaves and bark	Highly demanded in several countries, agarwood is further processed into perfumes, incenses, and ornamental displays and used as a raw material in traditional and modern medicines	Lee and Mohamed (2016)

## Conclusion

The present study provides vital information for future local and international conservation status assessments and plays a role in filling data gaps for many species living in such an understudied ecosystem such as forests over limestone. For example, some species recorded in this study represent new island or locality records. This includes *H. wenzeliana* and *C. sumuroi*, which are both not well-known and have not yet been categorized in local and international conservation status assessments. The new distribution records presented here contribute data that will be valuable in not only in conservation status assessments but also for management planning.

The Cave Management, Protection and Conservation Strategy and Action Plan (CMPCSAP) has laid out a framework for the conservation and sustainable management of Philippine caves, cave resources, and karsts, and it also has provisions for formulating and implementing policies regarding the sustainable use of cave and karst resources, as well as the sustainable management of selected caves and karsts as ecotourism areas (DENR-BMB, 2019). One of the study sites in the present study, Linao Cave in Brgy. Sulangan, Guiuan, is a popular local tourist attraction, the management of which could be improved based on these guidelines. Moreover, Anore et al. (2019) proposed a community-based approach in a tourism development plan for Calicoan Island due to its reputation as the surfing capital of the Visayas. The various surfing competitions held here annually may attract more tourists, which in turn could encourage more development on the island that should be closely monitored and strictly managed to conserve the biodiversity of the area.

## Acknowledgments

The authors would like to thank DOST-PCAARRD and DOST-GIA for funding the program (no. N9A6323), and DOST-SEI for allowing ELC Villanueva to take part in this research program through the Career Incentive Program. The authors would also like to thank the GMRPLS-PAMB and DENR Region 8 for granting them the gratuitous permit (no. 2019-16) to conduct the study, the barangay councils of Baras, Ngolos, Pagnamitan, and Sulangan, and the kind people of Guiuan,

especially Tito Rambakod, for their assistance and hospitality. We also thank the UPLB Institutional Animal Care and Use Committee for granting us permit no. CAS-2019-016.

## References

- Adam, J.H., Mamat, Z., 2005. Floristic composition and structural comparison of limestone forests at three different elevations in Bau, Kuching, Sarawak, Malaysia. *J. Biol. Sci.* 5(4): 478-485.
- Alura, D.P., Alura, R.P.C., 2016. Regeneration of mangrove forest devastated by Typhoon Haiyan in Eastern Samar, Philippines. *Int. J. Curr. Res.* 8(6): 32373-32377.
- Anore, N.J.P., Bersamin, C.J.E., Catapang, I.M.M., Gatinga, G.E.M., Gomez, M.A.M., Robles, S.J.L., Mercado, J.M.T., 2019. Tourism development plan for the Calicoan Island: a community-based tourism (CBT) approach. *Journal of Tourism, Hospitality and Culinary Arts*, 11(1), pp.65-81.
- APG IV, 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Bot. J. Linn. Soc.* 181(1): 1-20.
- Arlott, N., 2018. *Birds of the Philippines: and Sumatra, Java, Bali, Borneo, Sulawesi, the Lesser Sundas and the Moluccas* (Collins Field Guides). Harper Collins UK.
- BCSP. Biodiversity Conservation Society of the Philippines (Eds.), 2020. *Philippine Red List of Threatened Wild Fauna Part I - Vertebrates*. Biodiversity Management Bureau, Department of Environment and Natural Resources, Philippines.
- BirdLife International, 2017. *Cacatua haematuropygia*. The IUCN Red List of Threatened Species 2017: e.T22684795A117578604. Retrieved on 23 December 2020 from <https://doi.org/10.2305/IUCN.UK.2017-3.RLTS.T22684795A117578604.en>.
- Cadiz, G.O., Buot, I.E. Jr., 2010. An enumeration of the vascular plants of Mount Tabunan, Cebu Island, Philippines. *Thailand Nat. Hist. Mus. J.* 4(2): 71-77.
- Canillas, R. 2018. eBird Checklist: <https://ebird.org/checklist/S64212514>. eBird: An online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. Retrieved on December 23, 2020.
- Canillas, R. 2018. eBird Checklist: <https://ebird.org/checklist/S64212178>. eBird: An online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. Retrieved on December 23, 2020.
- Canillas, R. 2019. eBird Checklist: <https://ebird.org/checklist/S64202705>. eBird: An online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. Retrieved on December 23, 2020.
- CITES. Convention on International Trade in Endangered Species of Wild Fauna and Flora. 2004. Consideration of proposals for amendment of Appendices I and II - *Aquilaria* spp. and *Gyrinops* spp. Proceedings of Thirteenth Meeting of the Conference of the Parties, Bangkok, Thailand.
- Corales-Ultra, O.G., Peja, R.P. Jr., Casas, E.V. Jr., 2019. Baseline study on the levels of heavy metals in seawater and macroalgae near an abandoned mine in Manicani, Guiuan, Eastern Samar, Philippines. *Mar. Pollut. Bull.* 149:110549.
- Cruz, R.V.O., Gonzalez, J.C.T., de Guia, A.P.O., Tiburan, C.L.J., Malabrigo, P.L.J., Balatibat, J.B., Cereno, R.P., Fernandez, D.A.P., Buhay, A.F.V., 2017. Vertebrate wildlife assessment, in: *Manual on Biodiversity Assessment and Monitoring System for Terrestrial Ecosystems: How-To Guidelines*. GIZ and DENR-BMB, Philippines.
- Day, M.J., Ulrich, P.B., 2000. An assessment of protected karst landscapes in Southeast Asia. *Cave Karst Sci.* 27: 61-70.
- Diesmos, A.C., Watters, J.L., Huron, N.A., Davis, D.R., Alcala, A.C., Crombie, R.I., Afuang, L.E., Gee-Das, G., Sison, R.V., Sanguila, M.B., Penrod, M.L., 2015. Amphibians of the Philippines, part I: checklist of the species. *Proc. Calif. Acad. Sci.* 62(20): 457-539.
- Di Benedetto, A., Molinari, J., Boschi, C., Benedicto, D., Cerrotta, M., Cerrotta, G., 2006. Estimating crop productivity for five ornamental foliage plants. *Int. J. Agric. Res.* 1(6): 522-533.

- del Hoyo, J., Elliott, A., Sargatal, J., Christie, D.A., Kirwan, G. (eds.), 2020. Handbook of the Birds of the World Alive. Lynx Edicions, Barcelona, Spain. Retrieved on 30 March 2020 from <http://www.hbw.com/>.
- DENR. Department of Environment and Natural Resources, 2017. Administrative Order 2017-11, Updated National List of Threatened Philippine Plants and Their Categories. Department of Environment and Natural Resources, Philippines. Retrieved on 07 October 2020 from <http://www.bmb.gov.ph/index.php/e-library/laws-and-policies/denr-administrative-orders/dao-2017-2019?download=197:denr-administrative-order-2017-11>.
- DENR. Department of Environment and Natural Resources, 2019. Administrative Order 2019-09, Updated National List of Threatened Philippine Fauna and Their Categories. Department of Environment and Natural Resources, Philippines. Retrieved on 07 October 2020 from <http://www.bmb.gov.ph/index.php/e-library/laws-and-policies/denr-administrative-orders/dao-2017-2019?download=383:denr-administrative-order-2019-09>.
- DENR-BMB. Department of Environment and Natural Resources - Biodiversity Management Bureau, 2019. Cave Management, Protection and Conservation Strategy and Action Plan (CMPCSAP) 2019-2028, Philippines. Retrieved on 07 October 2020 from <https://www.bmb.gov.ph/index.php/caves/programs-caves>.
- EDC. Energy Development Corporation, 2020. *Shorea negrosensis*. The IUCN Red List of Threatened Species 2020: e.T33144A68074543. Retrieved on 07 October 2020 from <https://dx.doi.org/10.2305/IUCN.UK.2020-1.RLTS.T33144A68074543.en>.
- Gonzalez, J.C.T., Layusa, C.A.A., Afuang, L.E., Duya, M.R.M., Heaney, L.R., Balete, D.S., Tabaranza, D.G.E., Española, C.P., van de Ven, W.A.C., Diesmos, A.C., Causaren, R.M., Diesmos, M.L.L., Lagat, R.T., Realubit, N.D.C., Sy, E.Y., Lit, I.L. Jr, Naredo, J.C.B., Lastica-Ternura, E.A., Pasicolan, S.A., Tagtag, A.M., De Leon, J.L., Lim, T.M.S., Ong, P.S., 2018. Review and update of the 2004 National List of Threatened Terrestrial Fauna of the Philippines. *Sylvatrop* 28: 73-144.
- Hilvano, N., Nelson, G.L.M., Coladilla, J.O., Rebancos, C.M., 2016. Household disaster resiliency on Typhoon Haiyan (Yolanda): the case of Manicani Island, Guiuan, Eastern Samar, Philippines. *Coast. Eng. J.* 58(1): 1640007-1-25.
- Ingle, N.R., Heaney, L.R., 1992. A key to the bats of the Philippine Islands. *Fieldiana Zool. (NS)* 69, 1–44.
- Kennedy, R., Gonzales, P.C., Dickinson, E., Miranda Jr, H.C., Fisher, T.H., 2000. A Guide to the Birds of the Philippines. Oxford University Press.
- Koch, A., Gaulke, M., Boehme, W., 2010. Unravelling the underestimated diversity of Philippine water monitor lizards (Squamata: *Varanus salvator* complex), with the description of two new species and a new subspecies. *Zootaxa* 2446(1), 1–54.
- Lee, S.Y., Mohamed, R., 2016. The origin and domestication of *Aquilaria*, an important agarwood producing genus. *Agarwood*, 1-20.
- Lillo, E.P., Fernando, E.S., Lillo, M.J.R., 2019. Plant diversity and structure of forest habitat types on Dinagat Island, Philippines. *J. Asia Pac. Biodivers.* 12(1): 83-105.
- Lillo, E.P., Malaki, A.B., Alcazar, S.M.T., Nuevo, R.U., Rosales, R., 2019. Native trees on Mount Lantoy Key Biodiversity Areas (KBA), Argao, Cebu, Philippines. *Philippine Journal of Science* 148(2), 359–371.
- Lin, I.I., Pun, I.F., Lien, C.C., 2014. “Category-6” supertyphoon Haiyan in global warming hiatus: contribution from subsurface ocean warming. *Geophys. Res. Lett.* 41 (23), 8547–8553.
- Losos, E.C., Leigh, E.G. (Eds.), 2004. Tropical Forest Diversity and Dynamism: Findings From a Large-Scale Plot Network. Chicago University Press, Chicago. 688 pp.
- Maryna O., Halyna T., Lyudmyla B., Natalia K., Anna G., Vladimir T., Zbigniew O., 2019. Evaluation of the Antibacterial Activity of Ethanollic Extracts obtained from *Aglaonema commutatum* Schott and its cultivars against *Citrobacter freundii*. *Agr.bio.div. Impr. Nut., Health Life Qual.* 2019: 154-164.
- Mendoza, A.B., Alura, D.P., 2001. Mangrove structure on the eastern coast of Samar Island, Philippines, in: Stott D.E., Mohtar R.H., Steinhardt G.C. (Eds.), Sustaining the Global Farm: Selected Papers from the 10th International Soil Conservation Organization Meeting, May 24-29 1999, West Lafayette. Purdue University and the USDA-ARS National Soil Erosion Research Laboratory, pp. 423-425.
- Moehring, D.M., 2013. The anti-proliferative properties of *Tradescantia zebrina*. *The FASEB Journal*. 27(1).

- Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A.B., Kent, J., 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858.
- Opryshko, M., Tkachenko, H., Buyun, L., Kurhaluk, N., Góralczyk, A., Tomin, V. and Osadowski, Z., 2019. Evaluation of the antibacterial activity of ethanolic extracts obtained from *Aglaonema commutatum* Schott and its cultivars against *Citrobacter freundii*. *Agr.bio.div. Impr. Nut., Health Life Qual.* (3): 154-164.
- Peja, R.P., Alcober, J.P.G., Corales, O.G., 2018. Levels of nickel in *Sargassum polycystum* (Fuciales, Sargassaceae) and *Thalassia hemprichii* (Alismatales, Hydrocharitaceae) in Manicani Island, Guiuan, Eastern Samar, Philippines. *Phil. J. Nat. Sci.* 21(2): 48-56.
- Pelser, P.B., Barcelona, J.F., Nickrent, D.L. (Eds.), 2011 onwards. Co's Digital Flora of the Philippines. [www.philippineplants.org](http://www.philippineplants.org).
- Peque, D.P., Hölscher, D., 2014. Rare tree species in nurseries across the Visayas, Philippines. *Int. J. Biodivers. Conserv.* 6(7): 589-599.
- Potter, N.S. III., 1953. The birds of Calicoan, Philippine islands. *The Wilson Bulletin* 65(4): 252-270.
- Quimio, J.M., 2016. Floral composition and timber stock forest in the Samar Island Natural Park. *Ann. Trop. Res.* 38(2): 30-51.
- Rickart, E.A., Heaney, L.R., Tabaranza Jr, B.R., 2002. Review of *Bullimus* (Muridae: Murinae) and description of a new species from Camiguin Island, Philippines. *J. Mammal.* 83(2): 421-436.
- Sanguila, M.B., Cobb, K.A., Siler, C.D., Diesmos, A.C., Alcala, A.C., Brown, R.M., 2016. The amphibians and reptiles of Mindanao Island, southern Philippines, II: the herpetofauna of northeast Mindanao and adjacent islands. *ZooKeys* (624): 1.
- Sodhi, N.S., Koh, L.P., Clements, R., Wanger, T.C., Hill, J.K., Hamer, K.C., Clough, Y., Tschardt, T., Posa, M.R.C., Lee, T.M., 2010. Conserving Southeast Asian forest biodiversity in human-modified landscapes. *Biol. Conserv.* 143: 2375-2384.
- Tang, J.W., Lu, X.T., Yin, J.X., Qi, J.F., 2011. Diversity, composition and physical structure of tropical forest over limestone in Xishuangbanna, Southwest China. *J. Trop. For. Sci.* 23(4): 425-433.
- Takagi, H., Esteban, M., 2016. Statistics of tropical cyclone landfalls in the Philippines: unusual characteristics of 2013 Typhoon Haiyan. *Nat. Hazards* 80 (1): 211–222.
- Taylor, J., Mate, E., Hutchinson, R.O., Eaton, J.A., 2015. *Frontiers of the Philippines: Eastern Visayas*. BirdingASIA, 24, pp.24-36.
- Tuyet, D., 2001. Characteristics of karst ecosystems of Vietnam and their vulnerability to human impact. *Acta Geol. Sin.* 75: 325-329.
- Verheij, E.W.M., Sukendar, 1991. *Gnetum gnemon* L. In: Verheij, E.W.M., and R.E. Coronel. 1991. *Plant Resources of South East Asia 2. Edible Fruits and Nuts*. PROSEA, Bogor, Indonesia.
- Welton, L.J., Siler, C.D., Linkem, C.W., Diesmos, A.C., Brown, R.M., 2010. Philippine bent-toed geckos of the *Cyrtodactylus agusanensis* complex: multilocus phylogeny, morphological diversity, and descriptions of three new species. *Herpetol. Monogr.* 24: 55-85.
- Welton, L.J., Travers, S.L., Siler, C.D., Brown, R.M., 2014. Integrative taxonomy and phylogeny-based species delimitation of Philippine water monitor lizards (*Varanus salvator* Complex) with descriptions of two new cryptic species. *Zootaxa* 3881(3): 201-227.