



## RESEARCH PAPER

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## Rapid assessment of avifauna and mammals in and near eight waterfalls in Agusan del Sur, Philippines

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Article published on August 14, 2018

**Key words:** Bats, Birds, Endemic, Non-volant, Vulnerable

### Abstract

To assess the species richness and endemism of birds and mammals, this study was conducted in and near eight waterfalls in Agusan del Sur, Philippines. A combination of mist netting, transect walk, and McKinnon's List methods were employed to document birds while mammals were documented through mist netting and key informant interviews. Fifty-nine species of birds and 13 mammalian species (nine bats and four non-Volant mammals) were recorded. Among the sampling sites, Siete Andanas Falls in Bunawan, Agusan del Sur had the highest species richness of birds (S=45) and mammals (S=7). The bird species, *Phapitreron leucotis* and *Todiramphus chloris* were present in all sampling sites. Out of the recorded bird species, 22 are endemic of which one is endangered (*Nisaetus pinskeri*) while two (*Buceros mindanensis* and *Lonchura oryzivora*) are vulnerable. The bat species, *Cynopterus brachyotis* and the endemic *Ptenochirus jagori* were present in seven sampling sites but absent in Suyak Falls in Esperanza, Agusan del Sur. Of the mammalian species recorded, five are endemic and two are threatened species. Conversion of land for agricultural farming and habitat loss due to slash and burn farming were the observed threats to the birds and mammals in the eight waterfalls in Agusan del Sur. The presence of the endemic and threatened species in the sampling sites indicates the need to take into consideration fauna and habitat conservation vis-à-vis ecotourism.

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## Introduction

The tropical ecosystem is a great reservoir of the biodiversity on Earth having higher species richness of plants and animals (Sodhi., 2004; Lomolino., 2010; Brown, 2014). The Philippines, a tropical country, is one of the globally rich regions in terms of biodiversity (Posa ., 2008; Mallari ., 2016) with high endemism and species diversity (Peterson ., 2000). The country's vertebrate biodiversity includes at least 231 species of land mammals of which 130 (56%) are endemic (Philippine Clearing House Mechanism, 2009) and 691 species of birds with 239 (35%) endemic (Wild Bird Club of the Philippines, 2017). These records could be attributed to the country's archipelagic setting where many islands and many individual mountains support unique assemblages of species (Duya., 2011). However, the Philippines has suffered widespread deforestation and habitat destruction (Posa., 2008) and because of these, populations of many wildlife species are rapidly declining and may eventually become extinct.

There are about 42 threatened terrestrial mammal species (Philippine Clearing House Mechanism, 2009) and 93 globally threatened bird species (Wild Bird Club of the Philippines, 2017) recorded in the Philippines. This indicates that further studies and survey on the biodiversity of fauna in the different habitats and ecosystem of the country are needed to be able to determine and assess the status and conservation of different species.

The waterfalls and surrounding areas are important habitats that may harbor unique species. However, the waterfall has an intrinsic appeal alone that attracts tourists from afar which may result to the disturbance of the area (Santos., 2016). Vertebrate surveys in waterfall habitats were conducted in Bega Watershed, Agusan del Sur by Balmores and Nuñez (2015) on the herpetofauna, Calimpong and Nuñez (2015) on the diversity of birds, Jalique and Nuñez (2015) on volant and non-volant mammals, Monteclaro and Nuñez (2015) on fruitbats, and Visto. (2015) on the diversity of ichthyofauna. In the waterfalls of

Cordillera Mountain Range, Brown. (2012) found a reptile species, *Parvoscincus leucospilos*. Plaza and Sanguila (2015) found an amphibian species, *Rhacophorus bimaculatus* in the waterfalls located in Mount Hilong-hilong, Agusan Del Norte. In spite of these data from surveys, insufficient information still exists on the diversity of the country's fauna in and near waterfalls particularly on the island of Mindanao, the country's second largest island. Agusan del Sur, the seventh largest province in the country located in Mindanao has rich natural resources contained in its vast agricultural land, forest, and marsh lands (Philippine Tourism, 2009).

Recent published reports in Agusan del Sur were on the forested and riparian areas (Sucaldito-Salibad and Nuñez, 2014). However, faunal diversity in waterfalls and vicinity in Agusan del Sur is still poorly documented.

This study was conducted to determine the species richness and endemism of birds and mammals in and near eight waterfalls of Agusan del Sur. Conservation status and threats to the fauna in the area were also recorded.

## Materials and methods

### Sampling area

This study was conducted in and near eight waterfalls in Agusan del Sur from November to December 2016 (Fig. 1). Agusan del Sur is the seventh largest province of the Philippines with a land area of 8,568 square kilometers located in the Caraga region of Mindanao (Department of the Interior and Local Government-Province of Agusan del Sur, 2012). Eight waterfalls located in the municipalities of Esperanza, Prosperidad, Rosario, Bunawan, and Sta. Josefa were surveyed.

### Sampling sites

Sampling site 1, Suyak Falls is located in Brgy. Nato, Esperanza, Agusan del Sur with coordinates of 8°36'33.2" N and 125°36'45.6" E at an elevation of 60 meters above sea level (masl).



**Fig. 1.** Map of the world (A) (www.artofanderson.com, 2014) and the Philippines (B) (www.google.com.ph/maps, 2018) showing the location of Agusan del Sur (highlighted in red) and the sampling areas (red dots) (C) (www.google.com.ph/maps, 2018).

Sampling site 2, Tugonan Waterfalls is located in Brgy. San Lorenzo, Prosperidad, Agusan del Sur with coordinates of 8°39'56.7" N and 126°00'51.2" E at an elevation of 95 masl.

Sampling site 3, Vidal Falls, is located in Brgy. San Lorenzo, Properidad, Agusan del Sur with coordinates of 8°40'40.3" N and 126°01'0.6" E at an elevation of 163 masl.

Sampling site 4, Panganan Falls is located in Brgy. Cabantao, Rosario, Agusan del Sur with coordinates 8° 22' 55.2" N and 126°02' 42.8" at an elevation of 59 masl.

Sampling site 5, Dinaguitan Falls is located in COSSEP Purok 11, Brgy. Bayugan III, Rosario, Agusan del Sur with coordinates of 8°18'44.6" N and 126° 05' 52.4" E atan elevation of 126 masl.

Sampling site 6, Maghilot Falls is located in in COSSEP Purok 11, Brgy. Bayugan III, Rosario, Agusan

del Sur with coordinates of 8°16' 01.8" N and 126°05' 00.4" E at an elevation of 275 masl.

Sampling site 7, Siete Andanas Waterfalls is located in Brgy. Bunawan Brook, Bunawan, Agusan del Sur with coordinates of 8°12' 28.1" N and 126°04' 05.6" E at an elevation of 73 masl.

Sampling site 8, Tugpan Falls is located in Brgy. Sayon, Santa Josefa, Agusan del Sur with coordinates of 7° 58' 08.5" N and 125° 58' 19.6" E at an elevation of 99 masl.

*Sampling methods and Identification*

Prior to faunal sampling, waterfall habitats were described using a habitat description form. The description includes the following parameters: coordinates and elevation based on actual GPS reading, presence/ absence of fallen trees in the surrounding area, and on-site disturbance.

*Sampling, Processing, and Identification of Samples*

Birds and bats were sampled using mist nets measuring 12 meters in length and four meters in width with four shelves to maximize capture efficiency. Actual counts/estimate counts of birds and bats were done.

For birds, transect walk and Mc Kinnons List methods were used to supplement mist netting data on birds. Morphological measurements such as total length, tail length, wing length, bill length, and tarsus length were recorded (Hedenstrom, 2004) using the vernier caliper while a pesola spring balance was used to determine the weight of the bird specimens. After identification, the birds were freed immediately.

To avoid capture of the same specimen, each captured bird specimen was marked with a nail polish on its claw/nail or tarsus (Calimpong and Nuñez, 2015). Birds were identified using Kennedy . (2000) and Fisher and Hicks (2000).

For mammals, bat samples were placed individually in cloth bags. Bat identification was based on the taxonomic key by Ingle and Heaney (1992). Morphometric data such as ear length, hind foot length, tail length, forearm length, and total length were recorded using a caliper (O'malley ., 2006).

Body weight was also taken using a Pesola spring balance. After identification, all the captured bats were marked on their wings to avoid recounting in

case of recapture. Sucrose solution was given to the bats to re-energize them before they are released.

For non-volant mammals, indigenous/local people were interviewed regarding the non-volant mammals present in the area to supplement capture and direct observation results. Existing threats to the fauna in the waterfall sites of Agusan del Sur were identified through direct observations and key informant interviews. The distribution and conservation status of the birds and mammals was determined based on the IUCN Red List of Threatened Species (2017) version 2017-3.

*Data analysis*

Paleontological Statistics Software (PAST) version 3.04 was used to calculate biodiversity indices of species and do cluster analysis.

**Results and discussion**

*Avifauna*

*Species richness and endemism*

Fifty-nine bird species belonging to 14 orders and 35 families were recorded (Table 1). This result is higher than the recorded number of birds (53 species) in Mt. Hamiguitan by Relox . (2011). However, species richness was lower compared to other habitats and areas in Mindanao, for instance in Agusan Marsh where 124 species were recorded (Sucaldito-Salibad and Nuñez, 2014) and in Bega Watershed where 83 species werefound (Calimpong and Nuñez, 2015).

**Table 1.** Species list, conservation status, and distribution of birds in the eight sampling sites of Agusan del Sur.

Order	Scientific name (old name)	D	CS	Sampling sites							
(Family)	Common name		IUCN 2017	Suyak falls	Tugonan falls	Vidal falls	Panganan falls	Dinaguitan falls	Maghilot falls	Siete Andanas falls	Tugpan falls
Accipitriformes											
(Accipitridae)	<i>Haliastur indus</i> Brahminy kite	R	LC		+	+	+	+	+	+	
	<i>Nisaetus pinskeri</i> ( <i>N. philippensis</i> , <i>Spizaetus philippensis</i> ) South Philippine Hawk-eagle	E	EN		+						
Bucerotiformes											
(Bucerotidae)	<i>Buceros mindanensis</i> Southern Rufous hornbill	E	V					+	+	+	
	<i>Penelopides affinis</i> Mindanao Hornbill	E	LC						+		

Caprimulgiformes										
(Apodidae)	<i>Collocalia troglodytes</i>	E	LC		+			+		+
	Pygmy swiftlet									
	<i>Cypsiurus balasiensis</i>	R	LC				+			
	Asian Palm Swift									
(Caprimulgidae)	<i>Lyncornis macrotis</i>	R	LC					+	+	+
	Great-eared nightjar									
(Hemiprocnidae)	<i>Hemiprogne comata</i>	R	LC		+	+	+			
	Whiskered treeswift									
Columbiformes										
(Columbidae)	<i>Chalcophaps indica</i>	R	LC		+	+	+	+	+	+
	Common Emerald Dove									
	<i>Geopelia striata</i>	R	LC		+	+		+		+
	Zebra dove									
	<i>Macropygia tenuirostris</i>	R	LC							+
	Philippine Cuckoo Dove									
	<i>Phapitreron leucotis</i>	E	LC	+	+	+	+	+	+	+
	White Eared Brown Dove									
	<i>Spilopelia chinensis</i>	R	LC					+	+	+
	Spotted dove									
Coraciiformes										
(Alcedinidae)	<i>Ceyx argentatus (Alcedo argentata)</i>	E	NT				+	+		+
	Silvery kingfisher									
	<i>Halcyon smyrnensis</i>	R	LC		+	+	+	+	+	+
	White-Throated kingfisher									
	<i>Pelargopsis capensis (Halcyon capensis)</i>	R	LC		+	+				
	Stork-billed Kingfisher									
	<i>Todiramphus chloris (Halcyon chloris)</i>	R	LC	+	+	+	+	+	+	+
	White-collared Kingfisher									
(Meropidae)	<i>Merops viridis</i>	R	LC							+
	Blue-throated Bee Eater									
Cuculiformes										
(Cuculidae)	<i>Centropus viridis</i>	E	LC		+			+		+
	Philippine coucal									
	<i>Hierococcyx pectoralis (Cuculus fugax)</i>	E	LC		+	+		+		+
	Philippine Hawk-cuckoo									
Falconiformes										
(Falconidae)	<i>Microhierax erythrogenys</i>	E	LC					+		+
	Philippine Falconet									
Galliformes										
(Megapodiidae)	<i>Megapodius cumingii</i>	R	LC							+
	Tabon Scrubfowl									
Gruiformes										
(Rallidae)	<i>Amaurornis phoenicurus</i>	R	LC					+		+
	White Breasted Waterhen									
Passeriformes										
(Acanthizidae)	<i>Gerygone sulphurea simplex</i>	E	LC		+	+	+	+	+	+
	Golden-bellied Gerygone									
(Artamidae)	<i>Artamus leucorhynchus</i>	R	LC		+	+		+		+
	White-breasted Woodswallow									
(Campephagidae)	<i>Pericrocotus flammeus</i>	R	LC							+
	Scarlet Minivet									

(Corvidae)	<i>Corvus macrorhynchos</i>	R	LC		+		+		+		+		+		+
	Large-billed Crow														
(Dicaeidae)	<i>Dicaeum australe</i>	E	LC		+		+		+		+		+		+
	Red keeled Flowerpecker														
	<i>Dicaeum hypoleucum pontifex</i>	E	LC								+				
	Buzzing Flowerpecker														
(Dicuridae)	<i>Dicrurus bracteatus</i>	R	LC												+
	Spangled Drongo														
(Estrildidae)	<i>Lonchura atricapilla</i>	R	LC		+		+		+		+		+		+
	Chestnut Munia														
	<i>Lonchura oryzivora</i>	I/R	V												+
	( <i>Padda oryzivora</i> )														
	Java Sparrow														
(Hirundinidae)	<i>Hirundo rustica</i>	R	LC		+		+		+						+
	Barn Swallow														
(Laniidae)	<i>Lanius cristatus</i>	R	LC												+
	Brown Shrike														
(Locustellidae)	<i>Megalurus palustris</i>	R	LC												+
	Striated Grassbird														
(Motacillidae)	<i>Motacilla cinerea</i>	R	LC												+
	Grey Wagtail														
	<i>Motacilla flava</i>	R	LC		+		+		+		+		+		+
	Western Yellow wagtail														
(Muscicapidae)	<i>Copsychus mindanensis</i>	E	LC		+		+		+		+		+		+
	Philippine Magpie Robin														
(Nectariniidae)	<i>Arachnothera flammifera</i>	E	LC		+		+								+
	Orange-tufted Spiderhunter														
	<i>Cinnyris jugularis</i>	R	LC		+		+		+		+		+		+
	( <i>Nectarinia jugularis</i> )														
	Olive-backed Sunbird														
	<i>Leptocoma sperata</i>	R	LC												+
	( <i>Nectarinia sperata</i> )														
	Purple-throated Sunbird														
(Oriolidae)	<i>Oriolus chinensis</i>	R	LC												+
	Black-naped Oriole														
(Passeridae)	<i>Passer montanus</i>	I/R	LC		+		+		+		+		+		+
	Eurasian Tree Sparrow														
(Pycnonotidae)	<i>Hypsipetes philippinus</i>	E	LC		+		+		+		+		+		+
	( <i>Ixos philippinus</i> )														
	Philippine bulbul														
	<i>Poliolophus urostictus</i>	E	LC												+
	( <i>Pycnonotus urostictus</i> )														
	Yellow-wattled Bulbul														
	<i>Pycnonotus goiavier</i>	R	LC		+		+		+		+		+		+
	Yellow-vented Bulbul														
(Rhipiduridae)	<i>Rhipidura nigritorquis</i>	E	LC		+		+		+		+		+		+
	Pied fantail														
(Sturnidae)	<i>Aplonis panayensis</i>	R	LC		+		+		+						+
	Asian Glossy Starling														
	<i>Sarcops calvus</i>	E	LC												+
	Coletto														
(Timaliidae)	<i>Macronous striaticeps</i>	E	LC		+		+								+
	Brown Tit-Babbler														
Pelecaniformes															
(Ardeidae)	<i>Ardea intermedia</i>	R/M	LC		+										
	Intermediate Egret														

	<i>Bulbulcus ibis</i>	R/M	LC							+	
	Cattle Egret										
	<i>Egretta garzetta</i>	R/M	LC			+	+		+	+	
	Little Egret										
	<i>Ixobrychus cinnamomeus</i>	R	LC			+					
	Cinnamon Bittern										
Piciformes											
(Picidae)	<i>Dryocopus javensis</i>	R	LC			+			+	+	
	White-bellied Woodpecker										
Psittaciformes											
(Psittacidae)	<i>Bolbopsittacus lumulatus</i>	E	LC	+	+		+	+	+	+	
	Guaibero										
	<i>Loriculus philippensis</i>	E	LC	+	+	+	+		+	+	
	Colasisi										
	<i>Tanygnathus megalorhynchus</i>	R	LC						+		
	Great-billed parrot										
Trogoniformes											
(Trogonidae)	<i>Harpactes ardens</i>	E	LC					+	+		
	Philippine Trogon										
Number of Species per site:				3	31	24	28	32	23	45	35
No. of endemic species:	22			1	14	10	9	14	11	19	12
Total No. of Species:	59										
No. of threatened species:		5									
Endangered:	1										
Vulnerable:	2										

Legend: D – Distribution (R – Resident; M – Migrant; E – Endemic; I – Introduced), CS – Conservation Status (LC – Least Concern; NT – Near Threatened; V – Vulnerable; EN – Endangered).

The species richness recorded in the different areas could be due to the habitat and vegetation types, presence and absence of disturbances, food availability, and climate. This is in line with the observation of Stevens and O'Connor (2006) and Jones . (2003) that species richness of an area could be attributed to abiotic factors such as habitat area, temperature, humidity, rainfall, latitude, and

altitude), and biotic factors (vegetation type) as well as food availability. The total number of bird species in this study includes three migrants, 34 residents, and 22 endemics (37.29% endemism).

The present data represent about 14% of the bird species recorded in Mindanao and 9% of the avifauna in the Philippines.

**Table 2.** Bird biodiversity indices in the eight waterfalls of Agusan del Sur.

Biodiversity Indices	Sampling sites							
	A	B	C	D	E	F	G	H
Taxa	3	31	24	28	32	23	45	34
Dominance	0.333	0.032	0.041	0.035	0.031	0.043	0.222	0.029
Shannon H' (H'=3.878)	1.099	3.434	3.178	3.332	3.466	3.135	3.807	3.526
Evenness	1	1	1	1	1	1	1	1

Legend: A-Suyak Falls; B-Tugonan Falls; C-Vidal Falls; D-Panganan Falls, E-Dinaguitan Falls; F-Maghilot Falls; G-Siete Andanas Falls; H-Tugpan Falls.

Among the sampled sites, Siete Andanas waterfalls located in Brgy. Bunawan Brooks in Bunawan municipality had the highest species richness (S=45) and endemic species of birds (19 endemic).

The total record of 45 species belongs to 14 orders and 32 families including the two endemic species, Southern Rufous Hornbill, *Buceros mindanensis*, which is also a vulnerable species and the near



threatened Silvery Kingfisher, *Ceyx argentatus*. The Java Sparrow, *Lonchura oryzivora*, a resident and vulnerable species was also recorded in Siete Andanas falls. The high species richness is attributed to lesser anthropogenic disturbances since there is only minimal population of locals living around the falls and the path to reach the falls is quite difficult. In addition, slightly abundant forest patches with

varying elevation in the area provide different micro-habitats, niches, and source of food that are essential to the survival of a wide variety of bird species (Mulwa ., 2012).

The presence of these endemic and globally threatened species indicates the importance of this site as a refuge to the avifaunal population.

**Table 3.** Species list, conservation status, and distribution of Mammals in theeight sampling sites of Agusan del Sur.

Species	Common name	D	CS	Sampling Sites							
				Suyak falls	Tugonan falls	Vidal falls	Panganan falls	Dinaguitan falls	Maghilot falls	Siete Andanas falls	Tugpan falls
Volant MAMMALS											
Chiroptera											
Pteropodidae											
<i>Cynopterus brachyotis</i>	Lesser Short-nosed Fruit Bat	R	LC		+	+	+	+	+	+	+
<i>Eonycteris spelaea</i>	Common Nectar Bat	R	LC				+	+			
<i>Haplonycteris fischeri</i>	Philippine Pygmy Fruit Bat	E	LC					+	+		
<i>Macroglossus minimus</i>	Lesser Long-tongued Fruit Bat	R	LC			+	+		+	+	
<i>Megaerops wetmorei</i>	White-collared Fruit Bat	R	V								+
<i>Ptenochirus jagori</i>	Greater Musky Fruit Bat	E	LC		+	+	+	+	+	+	+
<i>Ptenochirus minor</i>	Lesser musky fruit bat	E	LC					+		+	
<i>Rousettus amplexicaudatus</i>	Geoffroy's Rousette	R	LC			+	+				+
Rhinolophidae											
<i>Rhinolophus philippinensis</i>	Large-eared Horseshoe Bat	R	LC	+							
NON-VOLANT MAMMALS											



Carnivora Viverridae										
* <i>Paradoxurus hermaphroditus</i>	Common	R	LC					+	+	
Cetartiodactyla Suidae										
* <i>Sus philippensis</i>	Philippine	E	V					+		
Dermoptera										
Cynocephalidae										
* <i>Cynocephalus volans</i>	Philippine	E	LC						+	
Primates Cercopithecidae										
* <i>Macaca fascicularis</i>	Nicobar	R	LC					+		
Total Number of Endemic Species										
	5		0	1	1	1	3	2	3	2
Total Number of Threatened Species										
	2		0	0	0	0	0	0	1	1
Total Number of Volant Species										
	9		1	2	4	5	5	4	4	4
Total Number of Non-Volant Species										
	4		0	0	0	0	0	0	3	2
Overall Total Number of Species										
	13		1	2	4	5	5	4	7	6

Tugpan waterfalls of the municipality of Sta. Josefa has the second highest species richness of birds (35 species) and it is herewhere the Philippine endemic and near threatened species, *Ceyx argentatus* was recorded. This result was observed to be due to the presence of diverse vegetation around the falls. However, the site is highly prone to anthropogenic disturbances since the distance of the falls from the community is roughly 1.5km and the local community is using the falls as a swimming area due to its pool-like structure and oftentimes garbage is left in the site. Also, some parts of the mountain near the falls are already converted into agricultural land and according to Soka . (2013), a higher abundance of birds in a terrestrial habitat might be brought by the vegetation composition that forms the main element of their habitat. Thus, through this land conversion, habitat is lost for avian population. Moreover, the Tugonan falls in the municipality of Prosperidad has a moderately disturbed ecosystem due to the locals practicing slash and burn farming in the area partly surrounding the falls. Fruit bearing trees, which are essential food source for the birds, are being replaced with industrial trees such as *falcata*. But, despite

these disturbances, the endemic and endangered South Philippine Hawk-eagle, *Nisaetus pinskeri* was still recorded in the site. This shows that Tugonan falls could still provide refuge for threatened species. The resident and vulnerable species, Java Sparrow, *Lonchura oryzivora*, was also recorded in this falls. In Suyak falls, only three species of birds were recorded which was due to the heavy rainfall during the time of sampling. Weather conditions can highly affect capture probability by interfering with the activity of animals especially birds (Vickery and Bider, 1981; Vieira ., 2010). In addition, the duration of the sampling was relatively shorter in Suyak falls compared to the other sites also due to the weather.

In terms of endemism, there are 22 endemic species with 37.29% endemism. Among the endemic species, two are globally threatened, the endangered *Nisaetus pinskeri* and the vulnerable *Buceros mindanensis* while one resident species, *Lonchura oryzivora*, is vulnerable. Only two species, namely, the white-collared Kingfisher, *Todiramphus chloris* and the Philippine endemic *Phapitreron leucotis* were recorded in all sampling sites.

The presence of *T. chloris* hunting for small fishes in some of the sampled waterfalls suggests that the existence of this species within the sampled areas corresponds primarily to the presence of its prey.

The presence of *P. leucotis* was observed to be due to the scattered figs which were observed in all sampling sites that could serve as its food sources.

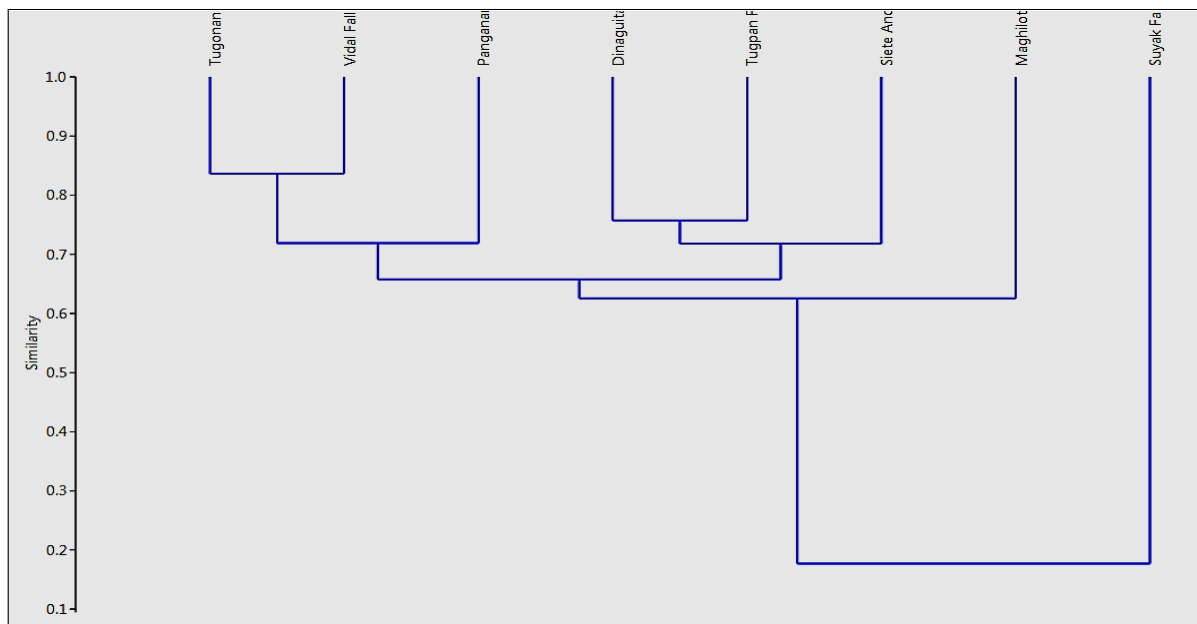
**Table 4.** Biodiversity indices of mammals in the eight waterfalls of Agusan del Sur.

Biodiversity indices	Sampling sites							
	A	B	C	D	E	F	G	H
Taxa (S=13)	1	2	4	5	5	4	7	6
Dominance	1	0.5	0.25	0.2	0.2	0.25	0.143	0.667
Shannon H' (H'=2.302)	0	0.693	1.386	1.609	1.609	1.386	1.946	1.792
Evenness	1	1	1	1	1	1	1	1

Legend: A-Suyak Falls; B-Tugonan Falls; C-Vidal Falls; D-Panganan Falls, E-Dinaguitan Falls; F-Maghilot Falls; G-Siete Andanas Falls; H-Tugpan Falls.

The same observation was obtained by Baptista. (2017) where they recorded *P. leucotis* feeding on a variety of fruits and seeds including figs. Furthermore, birds of the family Pycnonotidae such as the Philippine endemic *Hypsipetes philippinus*

(formerly *Ixos philippinus*) were observed in the seven sites but not in Suyak falls. Birds of family Pycnonotidae are known to adapt to seasonal availability of fruits (Azman., 2011).



**Fig. 2.** Cluster analysis (Bray-Curtis Cluster Analysis – paired group) of birds in the eight waterfalls of Agusan del Sur.

This observation concurs with the study of Paguntalan and Jakosalem (2008) where they found the Philippine bulbul (*Ixos philippinus*) feeding on the ripe fruits of *Ficus* sp. This implies that the presence of birds could be dependently due to the availability of food items and they choose to stay in

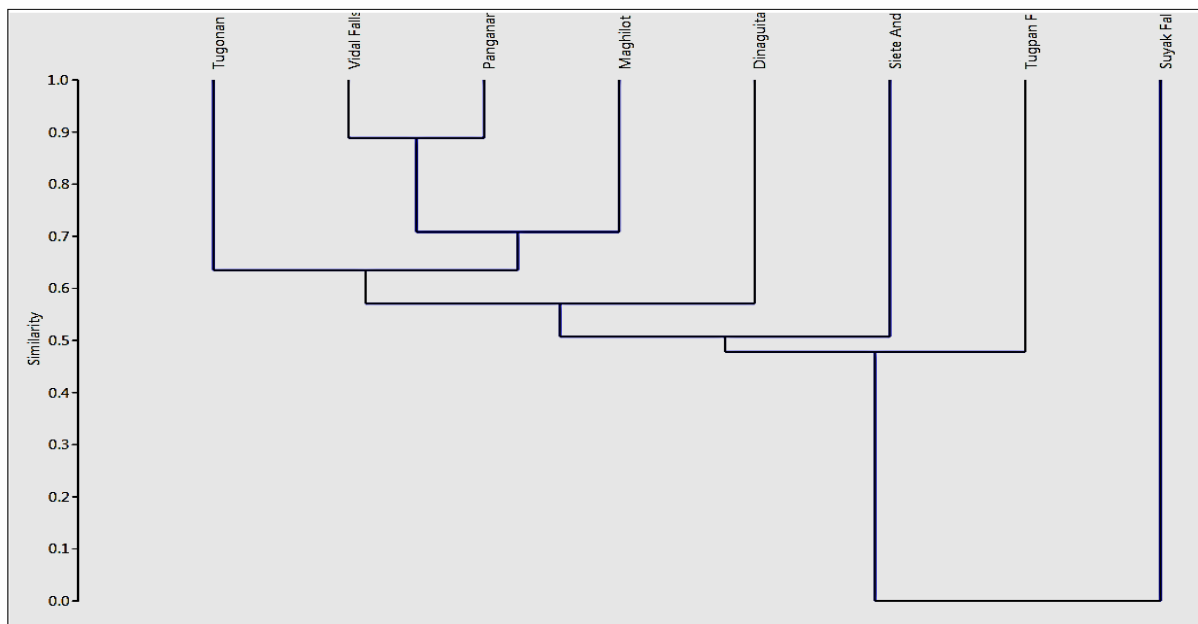
places where food is abundant (Alviola., 2010).

*Biodiversity Indices of birds*

The waterfall ecosystem in Agusan del Sur has high species diversity (H'=3.878) and even distribution of bird fauna (Table 2).

This is in accordance with the Shannon species diversity values of Ludwig and Reynolds (1988) that values higher than 3.5 indicate a very high diversity, values between 1.5 and 3.5 indicate moderate diversity, and values lower than 1 indicate low diversity. Among the sampled sites, Siete Andanas Falls had the highest species richness ( $S=45$ ) and species diversity ( $H'=3.807$ ). This indicates that this falls is a favorable habitat for the bird species because it is the least disturbed area with varied vegetation

cover and forest patches. This area could also serve as feeding sites of the bird species since fruit bearing trees are also present. This observation concurs with the study of Smith (1990) that significant diversity of species implies the uniqueness of the habitat including its physical condition (disturbance, food availability and moisture). In addition, the abundance and diversity of bird species are strongly dependent on the vegetation cover for feeding and breeding (Peris and Montelongo, 2014).



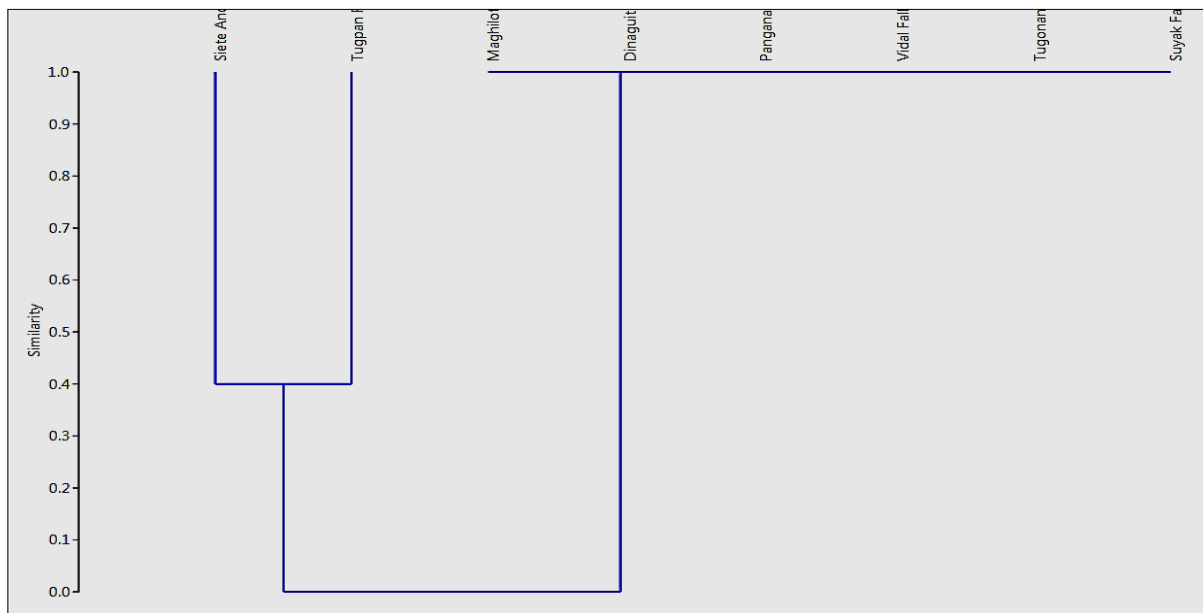
**Fig. 3.** Cluster analysis (Bray-Curtis Cluster Analysis – paired group) of volant mammals in the eight waterfalls of Agusan del Sur.

*Similarity of sampling sites*

Fig. 2 shows the similarity of the eight waterfall sites in Agusan del Sur in terms of bird composition. Tugonan falls and Vidals falls formed the first clade of the dendrogram and had the highest similarity percentage of >85% which means that these two sites shared mostly the same bird species. Both areas are located in the same barangay with moderately disturbed vegetation at low elevation. This concurs with the finding of Tubelis and Cavalcanti (2001) that sites having high similarity percentage could have a tendency of having the same species composition and same habitat type. Dinaguitan falls and Tugpan falls formed the second clade with a similarity percentage of >78%. Both sites are slightly disturbed with

abundant vegetation and low elevation which could still serve as microhabitat for some bird species.

Panganan Falls clustered to Tugonan and Vidals falls with a similarity percentage of >72% where 17 bird species are the shared species of the three sites. Maghilot falls is clustered to Tugonan, Vidals, Panganan, Dinaguitan, Tugpan, and Siete Andanas falls having a similarity percentage of >62% due to the 14 shared bird species. Furthermore, Suyak falls clustered to the other seven falls due to the two shared species, *Phapitreron leucotis* (White-eared Brown-dove) and *Todiramphus chloris* (White-collared kingfisher) which are present in all the sampling sites.



**Fig. 4.** Cluster analysis (Bray-Curtis Cluster Analysis – paired group) of non-volant mammals in the eight waterfalls of Agusan del Sur.

*Mammals*

*Species composition, endemism, and distribution*

Thirteen mammalian species (nine bats, four non-volant mammals) in five orders and six families were recorded in the eight waterfalls of Agusan del Sur (Table 3). Among the sampling sites, Siete Andanas Falls located in the municipality of Bunawan had the highest species richness which consists of seven species (four bats and three non-volant mammals) and three endemics. This site is relatively undisturbed with abundant vegetation and forest cover that offers a wide range of suitable microhabitats and food sources to mammals. This observation concurs with the findings of Caro (2006) and Van Weerd and Udo de Haes (2010) that areas having complex forest structure and variety of food availability are important habitats for mammalian species and one of the best reasons affecting species richness and abundance. In addition, the low elevation of Siete Andanas Falls also contributed to the mammalian richness because as what Nor. (2001) stated, mammalian species richness decreases gradually with increasing elevation. The same observation was also obtained by McCain (2007) whereas elevation increases, species richness of volant mammals' decreases. Also, the presence of endemic species

indicates that this site is an important habitat for mammals especially with the presence of a vulnerable species, *Sus philippensis*, which was recorded in this site based on key informant interview. Tugpan Falls had the second highest species richness consisting of six mammalian species (four volant and two non-volant) with two endemic and one vulnerable species (*Megaerops wetmorei*). This low-elevation area is prone to disturbances since the distance from the falls to the community is about 1.5km. Nevertheless, abundant vegetation was observed. However, the presence of threatened species in Siete Andanas Falls and Tugpan Falls indicates that these sites could be a refuge for threatened species. Suyak with one species and Tugonan Falls with two species had the lowest number of mammalian species recorded. The low number of mammalian species in Tugonan Falls was observed to be due to the disturbance near the area such as farming activities especially slash and burn farming while the low number of species in Suyak Falls was due to the rainfall during sampling days. According to Schipper. (2008) and Grelle (2005) degradation of habitat is the leading cause of wildlife declines and extinctions. In addition, Vickery and Bider (1981), Halle (2000), and Vieira. (2010) found that weather condition like rainfall and temperature

can affect the activity of mammals since their high surface-volume ratio facilitates the loss of heat and water through respiration which in turn affects capture probability. Thus, explaining the low number of species collected.

The bat species, *Cynopterus brachyotis* and the endemic species, *Ptenochirus jagori* were the most distributed species and present in seven sampling sites but not in Suyak Falls. According to Heaney (1998) *P. jagori* is abundant in primary forest, common in secondary forest, occasionally present in agricultural areas near forest, while *C. brachyotis* is abundant in agricultural areas, common in secondary forest, and usually uncommon or absent in primary forest. Both species forage and rely on figs and *Musa* (Monteclaro and Nuñez, 2015) which are abundant in the sampling sites. The absence of *C. brachyotis* and *P. jagori* in Suyak falls is attributed to the rainfall which occurred during sampling. The two vulnerable species, *Megaerops wetmorei* was only present in Tugpan falls and *Sus philippensis* in Siete Andanas Falls. *M. wetmorei* was also recorded in Bega Watershed, Agusan del Sur at an elevation of 225-320 masl (Monteclaro and Nuñez, 2015) and in North Cotabato having new altitudinal record of 58 masl (Achondo, 2014). Although *M. wetmorei* is generally widespread, its population was already observed to be declining (Heaney, 2010). In the case of *Sus philippensis*, most of its remaining populations are now widely fragmented and declining, as a result of former widespread commercial logging operations, agricultural expansion (particularly slash-and-burn cultivation or “kaingin”), (Heaney and Meijaard, 2017). In addition, *S. philippensis* hunted for direct consumption and trade (Scheffers, 2012), thus indicating that conservation and protection of *S. philippensis* in its habitats is needed.

Five endemic species (38.46% endemism), namely, *Haplonycteris fischeri*, *Ptenochirus jagori*, *Ptenochirus minor*, *Cynocephalus volans* and *Sus philippensis* were documented. *Haplonycteris fischeri* was only found in Dinaguitan and Maghilot Falls, *Ptenochirus minor* was only recorded

Dinaguitan and Siete Andanas Falls, and *Cynocephalus volans* only in Tugpan Falls. The presence of these endemic species especially the vulnerable species indicates the need for protection of the area.

#### *Threats to the Birds and Mammals in and near eight Waterfalls in Agusan del Sur*

Existing threats to the vertebrate fauna in the eight waterfalls of Agusan del Sur were observed to be brought mainly by human activities such as conversion of land for agricultural farming, using the falls as a swimming area leaving garbage in the site, and slash-and burn farming. These activities can negatively affect the daily activities of birds and mammals since they are highly intolerant of habitat disturbance. Slash and burn farming could likely lead to the extinction of many Philippine fauna (Suarez and Sajise, 2010) including birds and mammals. With these, there is a need to protect and conserve the area for the survival of the avifauna and mammals especially the endemic and threatened species.

#### **Conclusion**

The eight waterfalls of Agusan del Sur have high species richness of birds and mammals. The presence of many endemic species and five threatened species (three birds, two mammals) indicates that the waterfall ecosystem provides good habitats for birds and mammals. Siete Andanas Falls had the highest species richness of birds and mammals.

The bird species, *Phapitreron leucotis* and *Todiramphus chloris* were the most distributed species occurring in all the sampling sites. Conversion of surrounding land to farmland and slash and burn farming are the major threats to the vertebrate fauna in the eight waterfalls of Agusan del Sur.

#### **References**

Achondo MJMM, Casim LF, Tanalgo KC, Agduma AR, Bretaña BLP, Supremo JP, Mancao LS, Salem JGS, Bello VP. 2014. Occurrence and abundance of fruit bats in selected conservation areas of North Cotabato, Philippines. Asian Journal of Conservation Biology **3**, 3–7.

- Alviola GL, Del Rosario BI, Otadoy JB, Ibañez JC.** 2010. Birds of Malagos Watershed, Southeastern Philippines. *Asian Journal of Biodiversity* **1(1)**, 36-48. <http://dx.doi.org/10.7828/ajob.v1i1.102>
- Azman NM, Latip NSA, Sah SAM, Akil MAMM, Shafie NJ, Khairuddin NL.** 2011. Avian diversity and feeding guilds in a secondary forest, an oil palm plantation and a paddy field in riparian areas of the Kerian river basin, Perak, Malaysia. *Tropical Life Sciences Research* **22(2)**, 45-64.
- Balmores M, Nuñez OM.** 2015. The Reptiles of Bega Watershed of the Province of Agusan Del Sur in the Philippines. *World Journal of Environmental Biosciences* **4(2)**, 50-61.
- Baptista LF, Trail PW, Horblit HM, Kirwan GM, Garcia EFJ.** 2017. White-eared Brown-dove (*Phapitreron leucotis*). In: del Hoyo, J, Elliott A, Sargatal J, Christie DA, de Juana E, Eds. *Handbook of the Birds of the World Alive*. Lynx Edicions, Barcelona. Retrieved on February 28, 2018 from <https://www.hbw.com/node/54284>
- Brown JH.** 2014. Why are there so many species in the tropics?. *Journal of Biogeography* **41(1)**, 8–22. <http://dx.doi.org/10.1111/jbi.12228>
- Brown RM, Oliveros CH, Siler CD, Fernandez JB, Welton LJ, Buenavente PAC, Diesmos MLL, Diesmos AC.** 2012. Amphibians and Reptiles of Luzon Island (Philippines), VII: Herpetofauna of Ilocos Norte Province, Northern Cordillera Mountain Range. *Check List: Journal of species lists and Distribution* **8(3)**, 469-490. <http://dx.doi.org/10.15560/8.3.469>
- Calimpong DMT, Nuñez OM.** 2015. Avifaunal diversity of Bega Watershed, Prosperidad, Agusan del Sur, Philippines. *Journal of Biodiversity and Environmental Sciences* **6(4)**, 385-400.
- Caro TM.** 2006. Factors Affecting the Small Mammal Community Inside and Outside Katavi National Park, Tanzania. *Biotropica* **34(2)**, 310-318. <https://doi.org/10.1111/j.1744-7429.2002.tb00542.x>
- Department of the Interior and Local Government-Province of Agusan del Sur.** 2012. *Geography of Agusan del Sur*. Retrieved on February 28, 2018 from <http://www.agusandelsur.gov.ph/index/about-pgas/2011-11-17-16-33-44/2011-08-15-05-52-37/geography-demography>
- Duya MRM, Duya MV, Alviola PA, Balete DS, Heaney LR.** 2011. Chapter 4: Diversity of Small Mammals in Montane and Mossy Forests on Mount Cetaceo, Cagayan Province, Luzon. *Fieldiana Life and Earth Sciences* **2**, 88-95. <https://doi.org/10.3158/2158-5520-2.1.88>
- Fisher T, Hicks N.** 2000. A photographic guide to the birds of the Philippines. New Holland Publishers (UK) Ltd, p. 140.
- Grelle CEV.** 2005. Predicting extinction of mammals in the Brazilian Amazon. *Oryx* **39**, 347- 350. <https://doi.org/10.1017/S0030605305000700>.
- Halle S.** 2000. Ecological relevance of daily activity patterns. In: Halle S, Stenseth NC, Eds. *Activity patterns in small mammals: an ecological approach*. Berlin, Springer-Verlag, 67-90 p.
- Heaney LR, Balete DS, Dollar ML, Alcalá AC, Dans A.L, Gonzales PC, Ingle NR, Lepiten MV, Oliver WLR, Ong PS, Rickart EA, Tabaranza Jr BR, Uzzurum RCB.** 1998. A synopsis of the Mammalian Fauna of the Philippine Islands. *Fieldiana: Zoology* **88**, 1-61. <https://doi.org/10.5962/bhl.title.3419>
- Heaney LR, Dolar ML, Balete DS, Esselstyn JA, Rickart EA, Sedlock JL.** 2010. Synopsis of Philippine mammals. The Field Museum of Natural History in co-operation with the Philippines Department of Environment and Natural Resources-Protected Areas and Wildlife Bureau. Retrieved on February 18, 2018 from [www.fieldmuseum.org/philippine\\_mammals](http://www.fieldmuseum.org/philippine_mammals)

- Heaney L, Meijaard E.** 2017. *Sus philippensis*. The IUCN Red List of Threatened Species 2017: e.T21176A44139795. Downloaded on 28 February 2018.  
<http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T21176A44139795.en>
- Hedenstrom A.** 2004. Migration and morphometrics of Temminck's Stint *Calidris temminckii* at Ottenby, southern Sweden. *Ringing and Migration* **22(1)**, 51-58.  
<https://doi.org/10.1080/03078698.2004.9674310>
- Ingle NR, Heaney LR.** 1992. A key to the bats of the Philippine Islands. *Fieldiana: Zoology* **69**, 1-44.  
<https://doi.org/10.5962/bhl.title.3504>
- IUCN Red List of Threatened Species.** 2017. The IUCN Red List of Threatened Species. Version 2017-3. Downloaded on 08February 2018 from [www.iucnredlist.org](http://www.iucnredlist.org).
- Jalique SMP, Nuñez OM.** 2015. The Non-Volant Mammals of Bega Watershed, Prosperidad, Agusan del Sur, Philippines. *Advances in Environmental Biology* **9(18)**, 109-119.
- Jones W, Hobbs H III, Wicks C, Currie R, Hose L, Kerbo R, Goodbar J, Trout J.** 2003. Recommendations and Guidelines for Managing Caves on Protected Lands. Karst Waters Institute. *Nature* **8**, 1-88.
- Kennedy RS, Gonzales PC, Dickinson EC, Miranda HC, Fisher TH.** 2000. A guide to the birds of the Philippines. Oxford University Press, New York, p. 369.
- Lomolino MV, Riddle BR, Whittaker RJ, Brown JH.** 2010. *Biogeography*. 4th edition. Sunderland MA: Sinauer Associates, p 878.
- Ludwig JA, Reynolds JF.** 1988. *Statistical Ecology: A Primer on Methods and Computing*. John Wiley and Sons, New York, p 337.
- Mallari NAD, Collar NJ, Mc Gowan PJK, Marsden SJ.** 2016. Philippine protected areas are not meeting the biodiversity coverage and management effectiveness requirements of Aichi Target 11. *Ambio* **45(3)**, 313-322.  
<https://doi.org/10.1007/s13280-015-0740-y>
- McCain CM.** 2007. Could temperature and water availability drive elevational species richness patterns? A global case study for bats. *Global Ecology and Biogeography* **16**, 1-13.  
<https://doi.org/10.1111/j.1466-822x.2006.00263.x>
- Monteclaro RAO, Nuñez OM.** 2015. Species Diversity of Fruit Bats in Bega Watershed, Prosperidad, Agusan del Sur, Philippines. *Journal of Biodiversity and Environmental Sciences* **6(4)**, 127-137.
- Mulwa RK, Bohning-Gaese K, Schleuning M.** 2012. High bird species diversity in structurally heterogeneous farmland in western Kenya. *Biotropica* **44(6)**, 801-809.  
<https://doi.org/10.1111/j.1744-7429.2012.00877.x>
- Nor SM, Batin Z, Akbar Z.** 2001. Elevational Diversity Pattern of Non-volant Small Mammals on Mount Nuang, Hulu Langat, Selangor. *Journal of Biological Sciences* **1**, 1081-1084.  
<https://doi.org/10.3923/jbs.2001.1081.1084>
- Nuñez OM, Non MLP, Makiputin RC, Oconer EP.** 2015. Species diversity of bats in Mt. Matutum protected landscape, Philippines. *Journal of Biodiversity and Environmental Sciences* **6(6)**, 377-390.
- O'Malley R, King T, Turner CS, Tyler S, Benares J, Cummings M, Raines P.** 2006. The diversity and distribution of the fruit bat fauna (Mammalia, Chiroptera, Megachiroptera) of Danjungan Island, Cauayan, Negros Occidental, Philippines (with notes on the Microchiroptera). *Biodiversity and Conservation* **15**, 43-56.



- Paguntalan LMJ, Jakosalem PG.** 2008. Significant records of birds in forests on Cebu island, central Philippines. *Forktail* **24**, 48-56.  
<https://doi.org/10.1007/s10531-004-2931-x>
- Plaza JL, Sanguila MB.** 2015. Preliminary report on the Anurans of Mount Hilong-hilong, Agusan Del Norte, Eastern Mindanao, Philippines. *Asian Herpetological Research* **6**, 18-33.  
<https://doi.org/10.16373/j.cnki.ahr.140037>
- Peris S, Montelongo T.** 2014. Birds and small urban parks: a study in a high plateau city. *Turkish Journal of Zoology* **38**, 316-325.  
<http://dx.doi.org/10.3906/zoo-1305-20>
- Peterson AT, Ball LG, Brady KW.** 2000. Distribution of the birds of the Philippines: biogeography and conservation priorities. *Bird Conservation International* **10(2)**, 149-167.
- Philippine Clearing House Mechanism.** 2009. Philippine Wild Fauna/Animals. Retrieved on February 28, 2018 from  
[www.chm.ph/index.php?option=com\\_content&view=article&id=51&Itemid=86&el\\_mcal\\_month=6&el\\_mcal\\_year=2017](http://www.chm.ph/index.php?option=com_content&view=article&id=51&Itemid=86&el_mcal_month=6&el_mcal_year=2017)
- Philippine Tourism.** 2009. Region xiii (Caraga) > Agusan del Sur. Retrieved from  
[www.tourism.gov.ph/SitePages/InteractiveSitesPage.aspx?siteID=71](http://www.tourism.gov.ph/SitePages/InteractiveSitesPage.aspx?siteID=71)
- Posa MRC, Diesmos AC, Sodhi NS, Brooks TM.** 2008. Hope for threatened tropical biodiversity: Lessons from the Philippines. *Bio Science* **58**, 231-240.  
<https://doi.org/10.1641/B580309>
- Relox RE, Leano EP, Camino FA.** 2011. Avifaunal assemblage in Mt. Hamiguitan, Davao Oriental, Mindanao Island, Philippines. *Journal of Environmental Science and Management* **14(1)**, 1-11.
- Santos MD, Anadon HML, Caballero MB, Inion SMJ, Matsuo AGM, Novelo JLD.** 2016. Assessing the Potential of Ambon-Ambon and Malagaslas Falls in Laurel, Batangas, Philippines as a Tourist Attraction. *International Journal of Management and Commerce* **3(2)**, 884-908.
- Scheffers BR, Corlett RT, Diesmos A, Laurance WF.** 2012. Local demand drives a bushmeat industry in a Philippine forest preserve. *Tropical Conservation Science* **5(2)**, 133-141.  
<https://doi.org/10.1177/194008291200500203>
- Schipper J, Chanson JS, Chiozza F, Cox NA, Hoffmann M, Katariya V, Lamoreux J, Rodrigues AS, Stuart SN, Temple HJ, Baillie J,** 2008. The status of the world's land and marine mammals: diversity, threat, and knowledge. *Science* **322**, 225-230.  
<https://doi.org/10.1126/science.1165115>
- Sucaldito-Salibad MP, Nuñez OM.** 2014. Significant records of birds in Agusan Marsh, Philippines with notes on the conservation importance of the area. *Advances in Environmental Sciences* **6(1)**, 26-43.
- Smith RL.** 1990. *Ecology and Field Biology*. 4th Edition. Harpercollins Publishers, New York, p. 922.
- Sodhi NS, Koh LP, Brook BW, Ng PKL.** 2004. Southeast Asian biodiversity: An impending disaster. *Trends in Ecology and Evolution* **19(12)**, 654-660.  
<https://doi.org/10.1016/j.tree.2004.09.006>
- Soka GE, Munishi PKT, Thomas MB.** 2013. Species diversity and abundance of avifauna in and around Hombolo Wetland in Central Tanzania. *International Journal of Biodiversity and Conservation* **5(11)**, 782-790.  
<https://doi.org/10.5897/IJBC2013.0614>
- Stevens NJ, O'Connor PM.** 2006. Abiotic and Biotic Factors as Predictors of Species Richness on Madagascar. *Primate Biogeography Developments in Primatology: Progress and Prospects*, p 269-300.

- Suarez RK, Sajise PE.** 2010. Deforestation, Swidden Agriculture and Philippine Biodiversity. *Philippine Science Letters* **3**, 91-99.
- Tan KH, Zubaid A, Kunz TH.** 2000. Fruit dispersal by lesser dog faced fruit bat *Cynopterus brachyotis* (Muller) (Chiroptera: Pteropodidae). *Malayan Nature Journal* **56(1)**, 57-62.
- Tubelis DP, Cavalcanti RB.** 2001. Community similarity and abundance of bird species in open habitats of a Central Brazilian Cerrado. *Ornitología Neotropical* **12**, 57-73.
- Van Weerd M, Udo de Haes HAU.** 2010. Cross-taxon congruence in tree, bird and bat species distributions at a moderate spatial scale across four tropical forest types in the Philippines. *Biodiversity and Conservation* **19(12)**, 3393-3411.  
<https://doi.org/10.1007/s10531-010-9902-1>
- Vickery WL, Bider JR.** 1981. The Influence of Weather on Rodent Activity. *Journal of Mammalogy* **62**, 140-145.  
<https://doi.org/10.2307/1380484>
- Vieira EM, Baumgarten LC, Paise G, Becker RG.** 2010. Seasonal patterns and influence of temperature on the daily activity of the diurnal neotropical rodent *Necromys lasiurus*. *Canadian Journal of Zoology* **88**, 259-265.  
<https://doi.org/10.1139/Z09-142>
- Visto LM, Nuñez OM, Magdamit AD.** 2015. Diversity of ichthyofauna in freshwater system in Bega Watershed, Prosperidad, Agusan del Sur, Philippines. *Journal of Biodiversity and Environmental Sciences* **7(1)**, 262-271.
- Wild Bird Club of the Philippines.** 2017. Checklist of Birds of the Philippines. Retrieved on February 28, 2018 from [www.birdwatch.ph/html/checklist/checklist.html](http://www.birdwatch.ph/html/checklist/checklist.html)
- www.artofanderson.com.** 2014. Simple Map of the World. Retrieved from [www.artofanderson.com/simple-map-of-the-world](http://www.artofanderson.com/simple-map-of-the-world)
- www.google.com.ph/maps.** 2018. Philippines. Retrieved on February 18, 2017 from