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Mangrove-associated terrestrial vertebrates in Puerto Princesa Bay, Palawan, Philippines

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Abstract

Ninety-one mangrove-associated terrestrial vertebrate species, consisting of 20 herpeto-fauna, 63 birds and 8 mammals were documented along the coast of Puerto Princesa Bay in Palawan, Philippines. Sampling stations in barangays Iwahig and Sta. Lucia showed the higher species diversity and evenness distribution patterns than the more urbanized mangrove areas of barangays Sicsican, Irawan and Tinguiban. Species were categorized on respective conservation status and from the total number of species documented, 15 were Palawan endemics, 20 migratory birds, and one invasive alien species. This study augments and updates information regarding the biodiversity of Puerto Princesa Bay in Palawan and highlights the value and vulnerability of mangrove forest and its unique wildlife. Further efforts to preserve and improve the number and quality of mangrove areas in Palawan to ensure the survival of its unique wildlife is highly suggested.

Keywords: Birds, Herpetofauna, Mammals, Mangroves, Vertebrates.

1. Introduction

More than a thousand species of terrestrial and semi-aquatic vertebrates such as birds, mammals, amphibians, and reptiles are widely distributed across the Philippines and nearly 40% of these are known to occur in Palawan [1-5]. Many of these species inhabit mangrove ecosystems, which are in rapid decline. Approximately 40% of mangrove-associated terrestrial vertebrate species worldwide are at risk of becoming extinct if mangrove areas continue to decrease in size and quality [6]. In order to formulate effective conservation and management strategies for naturally occurring vertebrate species in mangrove forest along Puerto Princesa Bay in Palawan, Philippines, species inventory should methodically be investigated. So far, little is known about the biodiversity and occurrence of terrestrial vertebrates in mangrove forests of the bay and in the province of Palawan in general, thus, this report provides an updated record of species found in the area.

2. Materials and Methods

2.1 The Study Site

Puerto Princesa Bay is located in the middle of the eastern coast of mainland Palawan Island. A survey of mangrove-associated vertebrates was conducted from April to August 2013 in five (5) major stations along the mangrove-forested areas of Puerto Princesa Bay (Fig. 1), with each station falling under the jurisdiction of different barangays in Puerto Princesa, namely, Tinguiban (09.7746°N, 118.7239°E), Sicsican (09.7783°N, 118.6969°E), Irawan (09.74482°N, 118.6942°E), Iwahig (09.6885°N, 118.71831°E) and Sta. Lucia (09.6687°N, 118.70571°E).

2.2 Sampling Method

Point count (100m radius for avifauna) and plot (100m² for herpetofauna) sampling techniques were used during the survey of mangrove-associated vertebrates. Mist nets and drift-fenced pitfall traps were additionally deployed to capture and empirically account for occurrence and distribution of volant mammals and herpetofauna, respectively. In total, 13 point count sites, eight plots, three pitfall trap stations and eight nights of mist net trapping were carried out. Species identification and classification were done using taxonomic references.

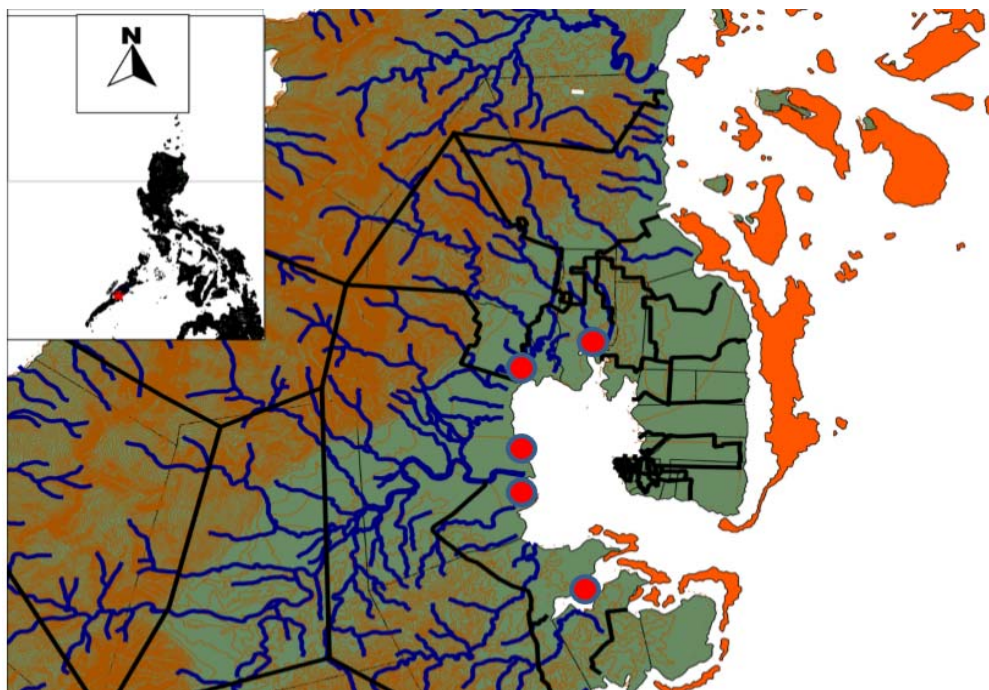


Fig 1: Map of the Philippines (inset) showing the location of Puerto Princesa Bay and the five sampling stations (red-filled circles).

2.3 Data Analysis

Species diversity and evenness distribution patterns for each station were calculated using the Shannon’s Index [7]. Relative densities of herpetofauna and avifauna were also calculated while capture rate was computed for mammalian fauna particularly of bats because capture data did not reach the minimum statistically required number of capture/recapture of individuals for density estimation. The capture rate for each bat species was expressed as the total number of captured individuals divided by the capture effort [8]. Simple linear regression [9] was estimated between the capture rate and the number of captured individuals from the first night to account for random sequence of species accumulation.

3. Results

3.1 Species abundance and ecological status

Results of the study suggest that 20% of herpetofauna, 24.5% of avifauna and 14% of mammalian fauna documented in the province of Palawan [4] were found in the five surveyed stations along the bay. This includes a total of 153 individuals of herpetofauna from 20 different species, five amphibian and 15 reptile species (Table 1). Two of these species, the *Limnonectes acanthi* Taylor, 1923 and *Cuora amboinensis* Riche, 1801 are categorized as vulnerable [5]. There were also a total of four Philippine endemic species recorded, which includes *Fejervarya vittigera* Wiegmann, 1834 and *Draco palawanensis* Kuhl, 1820. Two species, the *L. acanthi* and *Ingerophrynus philippinicus* Boulenger, 1887, in particular are known to occur only in Palawan and a few other surrounding islands.

Table 1: Maximum count per point of herpetofaunal species recorded from Puerto Princesa Bay, Palawan. *Refers to the conservation status and residency status in the Philippines of each species according to the IUCN Red List (2013): LC - Least Concern, VU - Vulnerable, ^E- Endemic.

Genus	Species	Common Name	Status*	Maximum Count per Point (within 100m radius)				
				Sta. Lucia	Irawan	Sicsican	Tinguiban	Iwahig-Bucana
<i>Boiga</i>	<i>dendrophila</i>	Mangrove snake	LC			1		4
<i>Bronchocela</i>	<i>cratellata</i>	Green crested lizard		1				1
<i>Cerberus</i>	<i>schneiderii</i>	Dog-faced water snake	LC			1		5
<i>Cuora</i>	<i>amboinensis</i>	Southeast Asian box turtle	VU	1				
<i>Dendrelaphis</i>	<i>marenae</i>	Maren’s bronzeback		2				1
<i>Draco</i>	<i>palawanensis</i>	Palawan flying dragon		3				4
<i>Emoia</i>	<i>atrocostata</i>	Mangrove skink		1	1	1	1	16
<i>Eutropis</i>	<i>multifasciata</i>	Many-striped skink		1	1	1	1	8
<i>Eutropis</i>	<i>indepressa</i>	Brown’s mabuya		2				4
<i>Fejervarya</i>	<i>cancrivora</i>	Asian brackish frog	LC	4	2	1	2	8
<i>Fejervarya</i>	<i>vittigera</i>	Common pond frog	LC	2				4
<i>Gehyra</i>	<i>mutilata</i>	Four-clawed gecko		2	1			2
<i>Gekko</i>	<i>gecko</i>	Tokay gecko		1	1	1	2	6

<i>Hemidactylus</i>	<i>frenatus</i>	Common house gecko	LC	2	1	1	1	4
<i>Hemidactylus</i>	<i>platyurus</i>	Flat-tailed house gecko		1		1	1	2
<i>Ingerophrynus</i>	<i>philippinicus</i>	Philippine toad	LC ^E	2	2	1	4	8
<i>Lamprolepis</i>	<i>smaragdina</i>	Emerald tree skink		1		1		4
<i>Limnonectes</i>	<i>palawanensis</i>	Palawan wart frog	LC ^E	3				1
<i>Limnonectes</i>	<i>acanthi</i>	Busuanga wart frog	VU ^E	2				
<i>Varanus</i>	<i>marmoratus</i>	Water monitor	LC ^E	1				6
			Total:	32	10	11	12	88

3.2 Herpetofauna

Iwahig station harbored the greatest number and density of amphibians and reptiles ($\mu = 0.4\text{--}4.5$; $SE = 0.45 \pm 0.35$) relative to other stations. Species diversity was highest in Sta. Lucia ($H' = 2.84$) followed by Iwahig ($H' = 2.67$), Sicsican ($H' = 2.30$), Irawan ($H' = 1.89$) and Tiniguiban ($H' = 1.80$), in decreasing order. Evenness scores, in decreasing order, were 1.00 for Sicsican, 0.94 for Irawan, 0.90 for Sta. Lucia, 0.86 for Tiniguiban and 0.80 for Iwahig.

3.3 Avifauna

A total of 685 individuals from 63 avifaunal species were observed and/or captured along the bay (Table 2). Among these, there were four near-threatened species (*Numenius arquata* Linn, 1758, *Cyornis lemprieri* Sharpe, 1884, *Tanygnathus lucionensis* Linn., 1766 and *Otus fuliginosus* Sharpe, 1888), one vulnerable species (*Mulleripicus pulverulentus* Temminck, 1826) and one critically endangered, the Philippine cockatoo, *Cacatua haematuropygia* Muller, 1776^[5]. There were also a total of 10 Philippine endemic species observed, including *Collocalia troglodytes* Gray, 1845, *Aethopyga shelleyi* Sharpe, 1884, *Rhipidura nigritorquis*

Vigors, 1831 and *C. haematuropygia*. Of these Philippine endemic species, six in particular are known to occur only in Palawan and a few other surrounding islands. These are *Dinopium everetti* Tweeddale, 1878, *Collocalia palawanensis* Stresemann, 1914, *Prionochilus plateni* Blasius, 1888, *Arachnothera dilutior* Sharpe, 1876, *C. lemprieri* and *O. fuliginosus*. There were also 20 migratory species documented, including *Phylloscopus fuscatus* Blyth, 1842), *Bulweria bulwerii* Jardine and Selby, 1828, *Actitis hypoleucos* Linn., 1758, *Ardea alba* Linn., 1758, *Charadrius leschenaultii* Lesson, 1826 and the near-threatened *N. arquata*, among others.

Count per sampling station ranged from 12 to 415 individuals with density ranging from 3.8 to 132 individuals/ha ($\mu = 0.2\text{--}6.5$; $SE = 1.15 \pm 0.65$). Sta. Lucia station exhibited the highest avifaunal density compared to other sites. Shannon's diversity index was highest in Sta. Lucia ($H' = 3.03$) followed by Iwahig ($H' = 3.01$), Sicsican ($H' = 2.46$), Tiniguiban ($H' = 2.25$) and Irawan ($H' = 2.02$), in decreasing order. Evenness scores, in decreasing order, were 0.95 for Tiniguiban, 0.90 for Sicsican, 0.84 for Iwahig, 0.63 for Irawan and 0.46 for Sta. Lucia.

Table 2: Maximum count per point of bird species recorded from Puerto Princesa Bay, Palawan. *Refers to the conservation status and residency status in the Philippines of each species according to the IUCN Red List (2013): LC - Least Concern, NT - Near Threatened, VU - Vulnerable, CR - Critically Endangered, ^M-Migratory, ^E- Endemic.

Genus	Species	Common Name	Status*	Maximum Count per Point (within 100m radius)				
				Sta. Lucia	Irawan	Sicsican	Tiniguiban	Iwahig-Bucana
<i>Actitis</i>	<i>hypoleucos</i>	Common sandpiper	LC ^M	7				9
<i>Aegithina</i>	<i>tiphia</i>	Common iora	LC	26	13	3	1	7
<i>Aethopyga</i>	<i>shelleyi</i>	Lovely sunbird	LC ^E					13
<i>Alcedo</i>	<i>atthis</i>	Common kingfisher	LC ^M		2			4
<i>Anthreptes</i>	<i>malacensis</i>	Brown-throated sunbird	LC	2				12
<i>Aplonis</i>	<i>panayensis</i>	Asian glossy starling	LC	2	15			32
<i>Arachnothera</i>	<i>dilutior</i>	Pale spiderhunter	LC ^E	11				12
<i>Ardea</i>	<i>alba</i>	Great egret	LC ^M		1	1		16
<i>Bulweria</i>	<i>bulwerii</i>	Bulwer's petrel	LC ^M	4	1			8
<i>Butorides</i>	<i>striata</i>	Striated heron	LC ^M	5	4	1		15
<i>Cacatua</i>	<i>haematuropygia</i>	Philippine cockatoo	CR ^E	8				8
<i>Cacomantis</i>	<i>merulinus</i>	Plaintive cuckoo	LC	1				6
<i>Centropus</i>	<i>sinensis</i>	Greater coucal	LC	2				6
<i>Ceyx</i>	<i>erithaca</i>	Oriental dwarf kingfisher	LC	3				2
<i>Chalcophaps</i>	<i>indica</i>	Emerald dove	LC	1				2
<i>Charadrius</i>	<i>leschenaultii</i>	Greater sand plover	LC ^M					4
<i>Charadrius</i>	<i>dubius</i>	Little ringed plover	LC ^M	11		1	1	14
<i>Cinnyris</i>	<i>jugularis</i>	Olive-backed sunbird	LC	10				17
<i>Clamator</i>	<i>coromandus</i>	Chesnut-winged cuckoo	LC ^M	1	2			4
<i>Collocalia</i>	<i>troglodytes</i>	Pygmy swiftlet	LC ^E			3	1	8
<i>Collocalia</i>	<i>palawanensis</i>	Palawan swiftlet	LC ^E	100		2	2	58
<i>Corvus</i>	<i>enca</i>	Slender-billed crow	LC	3				8
<i>Cyornis</i>	<i>lemprieri</i>	Palawan blue flycatcher	NT ^E	6	6			6
<i>Dicrurus</i>	<i>leucophaeus</i>	Ashy drongo	LC	6				23
<i>Dinopium</i>	<i>everetti</i>	Spot-throated flameback	LC ^E	4				4
<i>Ducula</i>	<i>aenea</i>	Green imperial pigeon	LC	3				6
<i>Egretta</i>	<i>garzetta</i>	Little egret	LC ^M	3		1	1	18
<i>Eudynamis</i>	<i>scolopaceus</i>	Asian koel	LC					5

<i>Ficedula</i>	<i>narcissina</i>	Narcissus flycatcher	LC ^M					8
<i>Gallirallus</i>	<i>striatus</i>	Slaty-breasted rail	LC					2
<i>Gallus</i>	<i>gallus</i>	Red junglefowl	LC					2
<i>Geopelia</i>	<i>striata</i>	Zebra dove	LC	10				8
<i>Gracula</i>	<i>religiosa</i>	Hill myna	LC	2				1
<i>Halcyon</i>	<i>coromanda</i>	Ruddy kingfisher	LC			1	1	4
<i>Heteroscelus</i>	<i>breviceps</i>	Grey-tailed tattler	LC ^M					2
<i>Ixos</i>	<i>palawanensis</i>	Sulfur-bellied bulbul	LC	28				21
<i>Lalage</i>	<i>nigra</i>	Pied triller	LC	4	2			17
<i>Lanius</i>	<i>cristatus</i>	Brown shrike	LC ^M	2				3
<i>Lonchura</i>	<i>leucogastra</i>	White-bellied munia	LC	4				8
<i>Lonchura</i>	<i>atricapilla</i>	Chestnut munia	LC	6				8
<i>Lyncornis</i>	<i>macrotis</i>	Great eared nightjar	LC	3				2
<i>Mesophoyx</i>	<i>intermedia</i>	Intermediate egret	LC ^M			2		12
<i>Mulleripicus</i>	<i>pulverulentus</i>	Grey slaty woodpecker	VU	8				6
<i>Muscicapa</i>	<i>ferruginea</i>	Ferruginous flycatcher	LC ^M	3				8
<i>Muscicapa</i>	<i>griseisticta</i>	Grey-streaked flycatcher	LC ^M					9
<i>Numenius</i>	<i>arquata</i>	Eurasian curlew	NT ^M		1			3
<i>Numenius</i>	<i>phaeopus</i>	Whimbrel	LC ^M	45				4
<i>Oriolus</i>	<i>chinensis</i>	Black-naped oriole	LC	3				4
<i>Orthotomus</i>	<i>sericeus</i>	Rufous-tailed tailorbird	LC	12		2	2	11
<i>Otus</i>	<i>fuliginosus</i>	Palawan scops-owl	NT ^E	1				1
<i>Pandion</i>	<i>haliaetus</i>	Osprey	LC ^M					2
<i>Passer</i>	<i>montanus</i>	Eurasian tree sparrow	LC	4				17
<i>Pelargopsis</i>	<i>capensis</i>	Stork-billed kingfisher	LC	10	1			13
<i>Phaenico-phaeus</i>	<i>curvirostris</i>	Chestnut-breasted malkoha	LC	2				4
<i>Phylloscopus</i>	<i>fuscatus</i>	Dusky warbler	LC ^M					21
<i>Prionochilus</i>	<i>plateni</i>	Palawan Flower-pecker	LC ^E					12
<i>Rhipidura</i>	<i>nigritorquis</i>	Philippine pied fantail	LC ^E	2		1	1	14
<i>Spilornis</i>	<i>cheela</i>	Crested serpent eagle	LC	2				5
<i>Stigmatopelia</i>	<i>chinensis</i>	Spotted dove	LC	2				12
<i>Tanygnathus</i>	<i>lucionensis</i>	Blue-naped parrot	NT	3				2
<i>Todiramphus</i>	<i>chloris</i>	Collared kingfisher	LC	6	3	1	1	15
<i>Treron</i>	<i>vernans</i>	Pink-necked green-pigeon	LC	34		1	1	46
<i>Tringa</i>	<i>glareola</i>	Wood sandpiper	LC ^M					12
			Total:	415	51	20	12	647

3.4 Mammals

Eight mammal species consisting of three bat species, one primate, three rodents and one carnivore were recorded along the bay (Table 3). In particular, large groups of *Acerodon leucotis* Souborn, 1950 were found roosting on trees in Sta. Lucia, as well as along the Iwahig River. These are large bats categorized as vulnerable^[5] and are known to occur only in the islands of Palawan, Balabac and Busuanga. The presence of *Sundsciurus steerii* Gunther, 1877, a squirrel endemic only to Palawan and surrounding islands, was also documented in Iwahig. However, the presence of *Mus musculus* Linn., 1758 in Sicsican could be an evidence of habitat disturbance and urbanization because this is considered to be an alien invasive species which may compete with other native rodents in the area^[10]. Consistent with the findings on species abundance of

herpetofauna, frequency of mammals, bats in particular, occurred mostly in Iwahig station. Sta. Lucia showed the second highest frequency, followed by Sicsican, Irawan, and Tiniguiban ($\mu = 2.8\text{--}37.2$; $SE = 8.1 \pm 6.3$). Shannon's diversity index was highest in Iwahig ($H' = 1.33$) followed by Sta. Lucia ($H' = 1.23$), Irawan ($H' = 1.00$), Sicsican ($H' = 0.54$) and Tiniguiban ($H' = 0.41$), in decreasing order. Evenness scores, in decreasing order, were 0.94 for Iwahig, 0.90 for Irawan, 0.86 for Sta. Lucia, 0.75 for Tiniguiban and 0.57 for Sicsican. Capture per unit effort (CPUE) of mammalian fauna varied among study sites ($F_{(4,35)} = 3.57, p = 0.02$), but post-hoc (Tukey) test showed that Sta. Lucia station had the highest CPUE followed by Iwahig, Tiniguiban, Irawan and Sicsican, in decreasing order.

Table 3. Maximum count per point of mammal species recorded from Puerto Princesa Bay, Palawan. *Refers to the conservation status and residency status in the Philippines of each species according to the IUCN Red List (2013): LC - Least Concern, VU - Vulnerable, ^E - Endemic, ^I - Introduced.

Genus	Species	Common Name	Status*	Maximum Count per Point (within 100m radius)				
				Sta. Lucia	Irawan	Sicsican	Tiniguiban	Iwahig-Bucana
<i>Acerodon</i>	<i>leucotis</i>	Palawan flying fox	VU ^E	12				27
<i>Cynopterus</i>	<i>brachiotis</i>	Common short-nosed fruit bat	LC	28	5	11	6	33
<i>Herpestes</i>	<i>brachyurus</i>	Short-tailed mongoose	LC	1				
<i>Macaca</i>	<i>fascicularis</i>	Long-tailed macaque	LC	2	2	1	1	12
<i>Macroglossus</i>	<i>minimus</i>	Dagger-toothed flower bat	LC	16	2	1		21
<i>Mus</i>	<i>musculus</i>	House mouse	LC ^I			1		
<i>Rattus</i>	<i>tiomanicus</i>	Malaysian field rat	LC	1				
<i>Sundasciurus</i>	<i>steerii</i>	Southern Palawan tree squirrel	LC ^E					1
			Total:	56	9	13	7	94

4. Discussion

The resulting list of species documented in this study probably underestimates the true diversity of terrestrial mammals in the area. Among mammals alone, there are 58 native species known to occur in the island of Palawan^[11] while this study only recorded seven (7) native mammal species. If only the more abundant species were captured during this study, there could be other species that additional sampling effort could have recorded. Biodiversity studies must ensure documentation of all species in the study area in order to gain sufficient data for more complex statistical and ecological analyses thus sampling effort should be increased and more areas up to nearby upland microhabitats and the estuaries are recommended to be included in future studies.

Mangrove-restricted species deemed to be at risk included the water monitor (*V. marmoratus*), mangrove snake (*Boiga dendrophila* Boie, 1827), dog-faced water snake (*Cerberus schneiderii* Schlegel, 1867), striated heron (*Butorides striata* Linn., 1758), ruddy kingfisher (*Halcyon coromanda* Latham, 1790) and collared kingfisher (*Todiramphus chloris* Boddaert, 1783). Some species not strictly mangrove-restricted were also at risk due to their dependence on mangrove ecosystem for feeding, nesting and migration^[6]. These include the whimbrel (*Numenius phaeopus* Linn., 1758), pink-necked green-pigeon (*Treron vernans* Linn., 1771) and the Philippine cockatoo (*C. haematuropygia*), which utilize mangrove areas as primary habitat.

Sampling stations in Iwahig and Sta. Lucia showed higher species diversity and evenness distribution patterns than the more urbanized areas of Sicsican, Irawan and Tiniguiban. Major culprits in the rapid degradation of mangrove ecosystems include coastal development, pollution and overexploitation^[6], which are most prominent in the urbanized areas of Sicsican, Irawan and Tiniguiban where biodiversity was lowest. Accordingly, mangrove-dependent species are more vulnerable to such threats due to evolution of specific characteristics for survival in this ecosystem. For example, some herpetofauna have salt-excreting glands to get rid of excess salt from their diet while many ground-foraging birds found in mangrove areas have developed unique morphological adaptations for feeding on crustaceans. Traits such as these make mangrove-restricted species less fit to adapt to other habitats if extirpated from their own.

Another threat to native mangrove-dependent terrestrial vertebrates is the presence of alien invasive species, the *M. musculus*. This species is a non-native resident of Palawan Island and is capable of reproducing and spreading at a rapid rate. This could lead to competition with native wildlife for many essential resources such as food and habitat and may even be carriers of diseases^[10]. However, there is also good news in the absence of other invasive species. In particular, there were no cane toads from genus *Rhinella* recorded in any of the study sites. This large toad was introduced as a means of controlling the numbers of the pest cane beetle but is now considered a direct competitor and even predator of smaller native amphibian species^[12].

5. Conclusion

This study on mangrove-associated terrestrial vertebrates served not only to augment and update information regarding the biodiversity of Puerto Princesa Bay but more importantly to highlight the value and vulnerability of such a highly specialized ecosystem. Further efforts to preserve and improve the number and quality of mangrove areas in Palawan must be undertaken to ensure the survival of its unique wildlife.

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