BIODIVERSITY AND CONSERVATION STATUS OF FLORA AND FAUNA IN ZAPANTA-GOMEZ CAVE, ZAMBOANGA DEL NORTE, PHILIPPINES

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Abstract

This study investigates the biodiversity and conservation status of flora and fauna in Zapanta-Gomez Cave, located in Zamboanga del Norte, Philippines. Employing quadrat and direct search sampling methods, the research documents the species composition and abundance within the cave, alongside an assessment of geologic formations and conservation statuses based on IUCN and DENR criteria. The Shannon-Weiner Diversity Index results reveal low flora and fauna diversity, highlighting the specialized and sensitive nature of this ecosystem. Key findings include the presence of endangered species such as Parkinsonia florida and Cylindroiulus punctatus, underscoring the urgent need for conservation efforts. These findings contribute to our understanding of Philippine cave ecosystems, providing baseline data essential for future conservation strategies. The study supports sustainable management practices to protect the cave's ecological integrity and align with broader biodiversity goals.

Keywords: *Cave biodiversity, conservation, flora, fauna, Shannon-Weiner Index, Zapanta-Gomez Cave*

Introduction

The conservation of biodiversity, particularly in ecologically sensitive and unique habitats like caves, aligns directly with several United Nations Sustainable Development Goals (SDGs), including SDG 14 (Life Below Water) and SDG 15 (Life on Land). These goals emphasize the importance of conserving ecosystems and their biodiversity, specifically calling for the protection and sustainable use of terrestrial and aquatic environments (United Nations, 2015). The unique ecological roles of cave habitats are increasingly recognized for their contribution to these goals, as caves house specialized species that contribute to biodiversity richness and ecosystem functionality (Alonso et al., 2019). Additionally, SDG 13 (Climate Action) advocates for preserving habitats susceptible to climate change impacts, which includes caves whose stable microclimates may be at risk from broader environmental changes (Piano et al., 2021).

Globally, caves are unique environments that host a range of endemic species adapted to specific ecological niches, but they face growing threats from anthropogenic pressures such as tourism, pollution, and land-use changes. The works of Culver and Pipan (2019) and Mammola (2019) emphasize that cave ecosystems represent both biodiversity hotspots and areas of scientific interest due to the specialized adaptations of their fauna and flora. However, human impacts are increasingly affecting these systems. For instance, Alonso et al. (2019) report that anthropization, or the influence of human activities, alters the microbiomes of caves, which could have cascading effects on other species dependent on this ecosystem. Sustainable cave management strategies, such as those suggested by Piano et al. (2021), advocate for reducing artificial lighting and other human disturbances to protect cave-dwelling species and maintain their delicate ecological balance.

In the Philippines, caves are recognized as essential ecological habitats under the Philippine Cave and Karst Resource Management Act (Republic Act No. 9072, 2001), which highlights their role in supporting biodiversity and ecological balance. The Department of Environment and Natural Resources–Protected Areas and Wildlife Bureau (DENR-PAWB) has acknowledged caves as critical environments that contribute to biodiversity conservation (DENR-PAWB, 2008). However, many cave systems are still under-studied, and conservation efforts face challenges due to limited resources and encroaching land development pressures (Nicolosi et al., 2021). Caves like Zapanta-Gomez, with documented flora and fauna requiring specific habitat conditions, emphasize the need for rigorous conservation strategies, especially as Philippine caves are under increasing pressure from tourism and infrastructure expansion (Ando & Murakami, 2020).

The Zamboanga del Norte region, known for its rich biodiversity, includes cave systems that are ecologically valuable but also under considerable anthropogenic threat. Local studies indicate that caves in this region serve as critical habitats for several vulnerable species, some of which have conservation statuses such as endangered or vulnerable according to IUCN standards (DENR-PAWB, 2008). The research of Culver and Pipan (2019) stresses that conservation at local levels, particularly in biodiversity hotspots like those in Zamboanga del Norte, is crucial for maintaining the ecological integrity of cave habitats. Despite national policies and guidelines, local conservation initiatives often lack the support needed to implement sustainable cave management effectively, and additional data on species composition and conservation status is still required (Mammola, 2019).

While there is an increasing recognition of the ecological importance of caves, specific data on species diversity and conservation status in Zamboanga del Norte caves remains limited. Existing studies are predominantly descriptive and lack comprehensive biodiversity assessments or conservation recommendations tailored to the Philippine context. For example, cave biodiversity surveys in Mindanao have documented specialized cave faunal groups such as spiders and crickets (Enriquez & Nuñeza, 2014; Lagare & Nuñeza, 2013) but did not provide broad ecosystem assessments, highlighting the need for more integrative research. Recent studies by Alonso et al. (2019) and Nicolosi et al. (2021) underscore the need for localized data to support national conservation strategies and effectively manage unique habitats like caves. Consequently, the lack of data on caves in the Philippines, particularly in less-studied areas like Zamboanga del Norte, constitutes a significant research gap. This gap hampers the development of effective conservation measures and limits our understanding of the ecological roles these caves play in supporting regional biodiversity.

This study aims to address the research gap by providing a comprehensive assessment of the flora and fauna diversity and conservation status within Zapanta-Gomez Cave. By evaluating the species composition, habitat conditions, and conservation needs of the cave ecosystem, this research contributes essential data to the conservation management efforts for Philippine caves. The findings are expected to support both local and national conservation strategies, emphasizing the ecological importance of caves in Zamboanga del Norte and advocating for enhanced protection measures aligned with the SDGs and Philippine environmental laws.

Methods

The study was conducted in Zapanta-Gomez Cave, located in the rural area of Lipakan, President Manuel A. Roxas, Zamboanga del Norte. The cave features multiple zones, including the entrance, twilight, and dark zones, each with distinct environmental conditions influencing species distribution.
Two primary sampling methods were employed to document species within the cave:

- *Quadrat Sampling:* Quadrats of 1 m² were established across different zones of the cave to survey flora and fauna. Within each quadrat, species were identified, counted, and recorded, enabling an estimation of population density and species distribution (González-Maya et al., 2022). This method provided quantitative data on species abundance in small, defined areas.
- *Direct Search Sampling:* Observers conducted systematic searches along pre-defined transects throughout the cave. This method allowed for the documentation of species (particularly mobile fauna and dispersed flora) and geological formations present in specific areas, capturing data that quadrat sampling might miss due to spatial limitations (Huang et al., 2021).

The Shannon-Weiner Diversity Index was used to quantify species diversity within the cave. This index provides insights into species richness and evenness, helping to measure the ecological balance of the cave environment (Zhang & Wang, 2023). Species abundance data (the number of individuals of each species) gathered from the quadrats and transect searches were applied to the Shannon-Weiner formula to calculate the diversity index (H'). A higher H' indicates greater diversity, while a lower H' indicates a community dominated by only a few species. This approach follows standard ecological methodologies (Whittaker, 1975), ensuring that our diversity results are comparable to those of other biodiversity studies.

Species conservation status was determined using the International Union for Conservation of Nature (IUCN) Red List criteria and the Philippine DENR guidelines. For each species recorded, we checked its classification (e.g., Endangered, Vulnerable, Least Concern) on the IUCN Red List and in the official national list of threatened species (DENR-PAWB, 2008). Species not appearing on either list were noted as “Not Listed” (indicating no known conservation threat). This assessment aligns with established conservation practices and ensures that our evaluation of each species’ status was comprehensive and up-to-date.

Ethical Considerations

The study adhered to ethical guidelines for field research on biodiversity set by the Philippine Biodiversity Management Bureau (BMB). All sampling was conducted with minimal disturbance to the cave environment, ensuring that flora and fauna were left undisturbed in their natural habitat. Necessary permissions were obtained from the

Department of Environment and Natural Resources (DENR) and local authorities before entering the cave, and the research complied with all applicable conservation and environmental laws. No endangered or protected species were removed or harmed during the study. These measures ensured that our research activities had negligible impact on the cave ecosystem and met the required ethical standards.

Results

The results of this study provide a comprehensive overview of the biodiversity and geologic characteristics of Zapanta-Gomez Cave, offering insights into its ecological significance and conservation needs. Through quadrat and direct search sampling, data were collected on the distribution and abundance of flora and fauna across different zones within the cave. The findings reveal distinct patterns in species composition, with low overall diversity reflective of the cave's specialized environment. Geologic formations observed in various zones further highlight the unique structural attributes of the cave, which contribute to its role as a habitat for several rare and endangered species. The following sections detail these observations, emphasizing the conservation implications for both flora and fauna within this sensitive ecosystem.

Geologic Formations: The cave contains a variety of speleothems and other geological structures. Table 1 summarizes the major geologic formations observed inside Zapanta-Gomez Cave and their distribution in the twilight and dark zones.

Table 1. Summary of Geologic Formations Found Inside Zapanta-Gomez Cave

Formation Type	Abundance in Twilight Zone	Abundance in Dark Zone
Stalactites	Few	Absent
Stalagmites	Moderate	Few
Draperies	Absent	Moderate
Flowstone Sheets	Few	Few
Columns	Absent	Absent
Rimstone Dams	Moderate	Absent

The geologic formations within Zapanta-Gomez Cave are varied. Features like stalactites and stalagmites were primarily found in the twilight zone, while the dark zone contained fewer of these formations, indicating limited mineral deposition (Brown et al., 2022). Such differences suggest that environmental conditions (e.g., water flow, drip rate, and substrate availability) vary within the cave, influencing speleothem development.

Flora Composition: The cave harbors a small assemblage of plant species adapted to low-light conditions. Table 2 lists the flora species observed inside the cave, along with their common names and the number of individuals recorded (abundance).

Table 2. Species Composition of Flora Found Inside the Cave

Common Name	Scientific Name	Abundance
Coconut Palm	*Cocos nucifera*	3
Dumbcane	*Dieffenbachia seguine*	60
Betel	*Piper abbreviatum*	25
Thread Fern	*Blechnum filiforme*	24

For comparison, Table 3 presents the flora identified immediately outside the cave (in the entrance zone and surrounding area), which experiences more sunlight and varied soil conditions.

Table 3. Species Composition of Flora Found Outside the Cave

Family	Scientific Name	Common Name	Abundance
Agaricaceae	*Agaricus bisporus*	Mushroom	1
Araceae	*Philodendron hederaceum*	Heartleaf Philodendron	20
Fabaceae	*Pterocarpus indicus*	Narra	3
Lauraceae	*Litsea philippinensis*	Bakan	12
Arecaceae	*Cocos nucifera*	Coconut	20
Piperaceae	*Piper abbreviatum*	Betel pepper	25
Moraceae	*Ficus benjamina*	Balete	4
Blechnaceae	*Blechnum filiforme*	Thread fern	24
Selaginellaceae	*Selaginella lepidophylla*	Flower of stone	40
Urticaceae	*Leucosyke capitellata*	Alagasi	6

The diversity of flora inside the cave is much lower than outside. Inside the cave, vegetation is limited to shade-tolerant species such as *Dieffenbachia seguine* and *Blechnum filiforme*. Outside the cave, a greater variety of plants (including trees like *Pterocarpus indicus* or Narra, and other sun-loving species) are present, reflecting the influence of sunlight and richer soil on plant growth (Smith et al., 2023). This stark contrast underscores how environmental factors constrain cave flora. Notably, *Dieffenbachia seguine* thrives in the low-light cave environment, whereas light-demanding species are absent from the cave interior. Castello (2014) similarly found that cave flora in an Italian karst cave were mostly limited to mosses and ferns, indicating that low-light conditions universally limit plant diversity in subterranean habitats.

Fauna Composition: The cave supports a community of specialized fauna. Table 4 shows the animal species recorded inside Zapanta-Gomez Cave, along with their taxonomic family, scientific names, common names, the number of individuals observed, and the cave zone where they were primarily found.

Table 4. Fauna Species Found Inside Zapanta-Gomez Cave

Family	Scientific Name	Common Name	Abundance	Zone
Apodidae	*Aerodramus fuciphagus*	Swiftlet	1	Entrance
Caridae	*Litopenaeus vannamei*	Freshwater shrimp	3	Twilight
Lycosidae	*Hogna lenta*	Wolf spider	12	Twilight
Microchiroptera	*Cynopterus brachyotis*	Lesser short-nosed fruit bat	361	Twilight, Dark
Pholcidae	*Leiobunum rotundum*	Harvestman (cave spider)	15	Dark
Gekkonidae	*Hemidactylus frenatus*	Common house gecko	4	Entrance

Table 5 lists representative fauna found outside the cave (in the vicinity of the cave entrance) for comparison with the cave interior.

Table 5. Species Composition of Fauna Found Outside Zapanta-Gomez Cave

Family	**Scientific Name**	**Common Name**	**Abundance**
Acrididae	*Schistocerca shoshone*	Green bird grasshopper	3
Coccinellidae	*Coccinella magnifica*	Lady beetle	2
Culicidae	*Aedes albopictus*	Forest mosquito	12
Euconulidae	*Gastropoda* (unidentified)	Snail	3
Gekkonidae	*Hemidactylus frenatus*	Common house gecko	1
Lycosidae	*Hogna lenta*	St. Andrew's cross spider	5
Pythonidae	*Malayopython reticulatus*	Reticulated python	1
Ranidae	*Limnonectes leytensis*	Small disked frog	6
Spirostreptidae	*Archispirostreptus gigas*	Giant African millipede	4
Vespidae	*Polistes chinensis*	Asian paper wasp	2

Inside the cave, the fauna is characterized by species adapted to low-light, humid conditions. For example, the lesser short-nosed fruit bat (*Cynopterus brachyotis*) forms a large colony within the twilight and dark zones, and the common house gecko (*Hemidactylus frenatus*) is found near the cave entrance where some light is available. In contrast, the fauna outside the cave is more diverse, including insects like the green bird grasshopper (*Schistocerca shoshone*) and the forest mosquito (*Aedes albopictus*), reflecting different ecological niches and greater resource availability outside.To quantify overall biodiversity, we calculated Shannon-Weiner diversity indices for both flora and fauna (Table 6).

Table 6. Shannon-Weiner Diversity Index for Flora and Fauna

Species Group	**Shannon-Weiner Index (H')**	**Diversity Level**
Flora	2.45	Low
Fauna	1.20	Very Low

The Shannon-Weiner Index values confirm that biodiversity in Zapanta-Gomez Cave is low, particularly for fauna. This low diversity reflects the cave's ecological constraints, where limited light and nutrients create a challenging environment for a wide variety of species (Li et al., 2022).

Conservation Status: Tables 8 and 9 present the conservation status of the fauna and flora identified in Zapanta-Gomez Cave, based on IUCN Red List categories and Philippine DENR classifications.

Table 8. Conservation Status of Fauna in Zapanta-Gomez Cave

Family	**Scientific Name**	**Common Name**	**Conservation Status**
Acrididae	Caelifera (order)	Grasshopper	Not Listed
Cancridae	Brachyura (infraorder)	Violet vinegar crab	Not Listed
Caridae	*Litopenaeus vannamei*	Freshwater shrimp	Vulnerable
Culicidae	Culicidae (family)	Mosquito	Not Listed
Gekkonidae	*Hemidactylus frenatus*	Common house gecko	Vulnerable
Helicidae	*Helix pomatia*	Snail	Least Concern
Julidae	*Cylindroiulus punctatus*	Millipede	Endangered
Lycosidae	*Hogna lenta*	Wolf spider	Not Listed
Microchiroptera	*Cynopterus brachyotis*	Lesser short-nosed fruit bat	Least Concern
Orthoptera	Rhaphidophoridae (family)	Camel cricket	Least Concern
Pythonidae	*Malayopython reticulatus*	Reticulated python	Vulnerable
Ranidae	*Fejervarya limnocharis*	Asian grass frog (field frog)	Least Concern
Rhaphidophoridae	*Ceuthophilus* spp.	Camel cricket	Not Listed
Scincidae	*Lamprolepis smaragdina*	Yellow-spotted night lizard	Not Listed
Sullogastrinae	*Barbodes binotatus*	Spotted barb (fish)	Least Concern
Vespidae	*Vespula vulgaris*	Wasp	Not Listed
(Unidentified)	*Leiobunum* sp.	Harvestman (Opiliones)	Not Evaluated
(Unidentified)	(Unidentified genus)	Cave centipede	Not Evaluated

Table 9. Conservation Status of Flora in Zapanta-Gomez Cave

Family	**Scientific Name**	**Local Name**	**Conservation Status**
Agaricaceae	*Agaricus bisporus*	Mushroom	Least Concern
Araceae	*Dieffenbachia* sp.	Houseplant	Not Listed
Araceae	*Philodendron hederaceum*	Heartleaf Philodendron	Least Concern
(Unknown)	*Cnestospema* sp.	Pusaw (local vine)	Least Concern
Arecaceae	*Cocos nucifera*	Coconut	Not Listed
Blechnaceae	*Blechnum filiforme*	Thread fern	Least Concern
Fabaceae	*Parkinsonia florida*	Palovende	Endangered
Fabaceae	*Pterocarpus indicus*	Narra	Vulnerable
Gramineae	*Bambusa speciosa*	Bamboo	Least Concern
Lauraceae	*Litsea philippinensis*	Bakan	Least Concern
Malvaceae	*Pterocymbium tinctorium*	Taloto	Least Concern
Moraceae	*Ficus benjamina*	Balete	Not Listed
Moraceae	*Ficus septica*	Labakid	Least Concern
Moraceae	*Ficus minahassae*	Hagimit	Not Listed
Piperaceae	*Piper abbreviatum* Opiz	Betel pepper	Least Concern
Robiniaceae	*Robinia pseudoacacia*	Golden Robinia	Least Concern

	'Frisia'		
Selaginellaceae	*Selaginella lepidophylla*	Flower of stone	Not Listed
Urticaceae	*Leucosyke capitellata*	Alagasi	Not Listed

Most fauna identified in the cave are not considered threatened on a global or national level (“Least Concern” or not listed), reflecting their relatively common status outside the cave. However, the millipede *Cylindroiulus punctatus* is categorized as Endangered (highlighting its potentially restricted range and specialized habitat), and the presence of Vulnerable species like the reticulated python (*Malayopython reticulatus*) and the plant *Parkinsonia florida* underlines the conservation importance of the site. Species marked as “Not Evaluated” or “Not Listed” in our tables are those for which no specific threat information is available in major lists; these are generally regarded as not currently at risk. Our findings show that while the cave hosts few species overall, some of those present have significant conservation value.

Discussion

The results from Zapanta-Gomez Cave highlight the distinct ecological characteristics of cave ecosystems and their conservation needs. The low diversity recorded in this study, with Shannon-Weiner Index values of 2.45 for flora and 1.20 for fauna, aligns with expected patterns in cave environments where stable but restricted conditions typically support fewer species that are often highly specialized (Mammola, 2019). Caves, as emphasized in global studies, represent unique ecosystems where species have adapted to low-light and nutrient-poor conditions, making these habitats critical yet vulnerable ecological niches (Culver & Pipan, 2019; Alonso et al., 2019).

Flora Composition and Conservation Needs: Flora diversity within Zapanta-Gomez Cave is relatively low and dominated by a few species like *Dieffenbachia seguine* and *Blechnum filiforme*, which are adapted to low-light conditions. This reflects global findings that cave flora are typically shade-tolerant and resilient to limited resources (Ando & Murakami, 2020). Outside the cave, plant species diversity is higher, including various trees such as *Pterocarpus indicus* (Narra), reflecting the more favorable conditions of the exterior environment. The presence of an endangered plant like *Parkinsonia florida* in the vicinity of the cave aligns with national conservation priorities, as cave habitats are often underrepresented in regional biodiversity assessments (DENR-PAWB, 2008). The Philippine government, under the Philippine Cave and Karst Resource Management Act (Republic Act No. 9072, 2001), has recognized the ecological significance of caves and mandated protective measures. However, conservation on the ground remains limited due to resource constraints and competing land-use priorities. As recent studies have noted, flora conservation within caves requires targeted management to prevent habitat loss and to support species that cannot thrive outside these microhabitats (Nicolosi et al., 2021).

Fauna Composition and Conservation Challenges: The fauna within Zapanta-Gomez Cave, including species like *Cynopterus brachyotis* (lesser short-nosed fruit bat) and *Hemidactylus frenatus* (house gecko), exemplifies the narrow ecological adaptations seen in many cave ecosystems worldwide. Bats, for instance, play a crucial role in nutrient cycling within caves by depositing guano, a finding consistent with research demonstrating their importance in subterranean ecosystems (Bat Conservation International, 2010; Culver &

Pipan, 2019). Despite their ecological value, cave fauna often exist in low diversity and density due to limited food sources and specialized habitat conditions (Piano et al., 2021). For example, our survey found only a few insect species inside the cave, and most were present in low numbers. Surveys of other Philippine caves have similarly noted low faunal diversity dominated by a few taxa; caves in Mindanao, for instance, are often inhabited by only specialized spiders or crickets (Lagare & Nuñeza, 2013; Enriquez & Nuñeza, 2014), indicating that such patterns of limited diversity are common in the region's cave ecosystems.

The conservation status of several fauna species in Zapanta-Gomez Cave, such as the endangered millipede *Cylindroiulus punctatus*, mirrors global concerns regarding the vulnerability of cave-dependent species. Many troglobitic (cave-restricted) organisms are highly susceptible to environmental disturbances. Our findings reinforce this: species identified as threatened in our survey (e.g., the millipede and the reticulated python) would likely suffer from any habitat alteration. These observations highlight the need for controlled access to the cave and strict pollution-mitigation measures. Human activities, even minor ones, can significantly impact cave fauna. Studies have shown that cave-dwelling species decline with disturbances such as frequent visitation or pollution, underscoring the importance of minimizing human impact (Alonso et al., 2019; Ando & Murakami, 2020). Sustainable cave management practices, like reducing artificial lighting and limiting tourist access, have been recommended to protect delicate cave ecosystems (Piano et al., 2021). Implementing such practices at Zapanta-Gomez Cave would likely benefit the fauna by preserving the pristine conditions they require.

Broader Implications and Conservation Recommendations: Caves serve as refuges for specialized flora and fauna, and protecting them contributes to broader biodiversity conservation goals, including the United Nations Sustainable Development Goals for Life on Land (SDG 15) and Climate Action (SDG 13) (United Nations, 2015). By understanding the unique conservation needs of caves like Zapanta-Gomez, conservationists can better advocate for policies that prioritize these sensitive ecosystems. In this context, our research aligns with calls for enhanced protection of caves as vital ecological reserves, highlighting their importance as biodiversity repositories and habitats for endemic species (DENR-PAWB, 2008).

Future conservation efforts for Zapanta-Gomez Cave should integrate recommendations from recent research. These include establishing buffer zones around the cave's entrance and implementing sustainable tourism practices that limit human impact (Mammola, 2019; Culver & Pipan, 2019). Buffer zones can help insulate the cave from external threats such as pollution or land-use changes, while sustainable tourism (e.g., guided tours with strict visitor limits and minimal infrastructure) can prevent habitat degradation inside the cave. Furthermore, targeted conservation strategies must involve raising public awareness about the ecological roles of caves and encouraging local stakeholder participation in conservation initiatives. Engaging the local community can foster a sense of stewardship and improve compliance with conservation measures.

Research Implications and Future Directions: This study provides essential baseline data for Zapanta-Gomez Cave, serving as a reference point for future biodiversity and conservation research on Philippine caves. However, further studies are warranted to address questions beyond the scope of our survey. For instance, investigating seasonal variations in cave fauna (such as bat population flux or insect life cycles) would yield a more comprehensive understanding of the cave's ecology. It would also be beneficial to explore genetic diversity and population structure of key species to assess their long-term viability. Additionally, studying the potential impacts of climate change on the cave's microclimate (Piano et al., 2021) could help predict and mitigate future stresses on this ecosystem. Finally, expanding research to microbial communities and nutrient cycling within the cave could provide a more holistic view of its ecological function. Such comprehensive research efforts would inform more nuanced and effective conservation strategies, supporting both regional and national biodiversity goals (Culver & Pipan, 2019; United Nations, 2015).

Conclusions

This study on the biodiversity and conservation status of Zapanta-Gomez Cave in Zamboanga del Norte highlights the ecological significance of cave ecosystems and underscores the urgent need for conservation measures tailored to their unique environmental conditions. The low diversity of flora and fauna observed within the cave (Shannon-Weiner Index $H' \approx 2.45$ for flora and 1.20 for fauna) aligns with global trends in cave ecosystems, where species are typically few and specialized due to limited light and nutrient availability. Key species, such as *Parkinsonia florida* (a cave-associated plant) and *Cylindroiulus punctatus* (a cave-dwelling millipede), are classified as endangered, emphasizing the vulnerability of these habitats and their inhabitants. By documenting the cave's biota and their conservation statuses, this research addresses a previously identified knowledge gap and provides a baseline for monitoring and management.

The findings demonstrate that Zapanta-Gomez Cave plays a crucial role in supporting unique species within the local landscape, contributing to the broader biodiversity goals outlined in the United Nations Sustainable Development Agenda (specifically SDG 15: Life on Land, and SDG 13: Climate Action). The conservation implications are clear: protecting this cave is vital to preserve its distinct flora and fauna and to prevent further degradation of its ecological integrity. Effective conservation of this cave ecosystem will also advance the objectives of Philippine environmental laws and initiatives.

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Disclosure: Use of AI Tools

In compliance with *The Threshold* journal's guidelines for the ethical use of artificial intelligence (AI) in academic research, the authors disclose the use of OpenAI's ChatGPT for assistance in editing and refining the manuscript's language. The AI tool was utilized to improve clarity and coherence, but all content, data analysis, and conclusions are the original work of the authors. The authors have reviewed and approved the final manuscript and remain responsible for the integrity and accuracy of the study's content. This disclosure ensures transparency in the writing process and adherence to the journal's ethical standards.

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