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RESEARCH ARTICLE

Herpetofaunal richness in Sungai Sedim Forest Eco Park: strengthening the park's ecotourism value

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ABSTRACT

The Sungai Sedim Forest Eco Park, located within compartment 16 of the Gunung Inas Forest Reserve in Kedah, was surveyed to document the diversity of herpetofauna and update existing species records. Given the rapid growth of ecotourism in Sungai Sedim Forest Eco Park, a robust and current ecological baseline is required to ensure sustainable management and the development of tourism products that emphasize biodiversity. Using the visual encounter survey (VES) and pitfall trapping method, the survey was carried out throughout five sampling sessions from July to October 2022. A total of 42 species, comprising 169 individuals, were successfully recorded by the study. Among the recorded species, *Hylarana labialis* was the most abundant, with 17 individuals, followed by *Leptobrachium hendricksoni* with 16 individuals, *Amolops larutensis* with 15 individuals, *Limnonectes blythii* and *Odorrana hosii* with 14 individuals each. Among reptile, *Gonocephalus grandis* with 10 individuals and *Cyrtodactylus consobrinus* and *Cyrtodactylus quadrivirgatus* with eight individuals each. Clear, shallow streams and freshwater swamp forests are associated with the abundance of *Hylarana labialis*. Furthermore, the survey highlights the ecological richness of the area, with the remaining individuals representing a variety of species, each with fewer than 10 individuals recorded. Diversity indices revealed a consistently high level of species diversity, with Simpson's Index (1-D) ranging from 0.8166 to 0.9282, and Shannon-Wiener Index (H') ranging from 1.851 to 2.81. Pielou's Species Evenness (J'), which ranged from 0.7549 to 0.917, indicates moderate to highly uniform species distribution across sessions. At the same time, the species accumulation curve did not reach the asymptote. The findings from the herpetofauna survey in Sungai Sedim Forest Eco Park strongly affirm the ecological value of the area and provide a scientific basis for expanding its ecotourism focus beyond adventure-based activities. The richness, diversity, and even distribution of species observed suggest a stable and relatively undisturbed habitat, positioning Sungai Sedim Forest Eco Park as an excellent location for conservation-oriented ecotourism.

1. INTRODUCTION

The Sungai Sedim Forest Eco Park (SSFEP) is located within the Gunung Inas Forest Reserve (GIFR) in Kedah. It exemplifies a site with high ecotourism due to its rich biodiversity and unique landscape. Infrastructure, such as the 925-meter-long canopy walk, the longest in the world (Mohd Nasir et al., 2023), further enhances its appeal. Recreational activities at Sungai Sedim Forest Eco Park have traditionally focused on adventure, including hiking, flying fox experiences, and water rafting (Mohd Nasir et al., 2023).

Outdoor recreation and ecotourism have gained significant attention in recent years. They serve as an avenue for promoting public well-being and as tools for sustainable management of natural resources (Mohd Nasir et al., 2023). In Malaysia, nature-based recreational activities are gaining popularity, particularly among youths. These demographics seek physical challenges, environmental engagement, and mental restoration (Shobri et al., 2021).

However, the park needs to make a strategic adaptation to develop into a truly sustainable ecotourism attraction. This shift necessitates actively incorporating its significant natural capital into the visitor experience rather than merely consuming scenic and adventure facilities. A solid, current ecological baseline generated through systematic biological surveys is a vital prerequisite for this development, providing the scientific basis required for establishing tourism attractions that promote biodiversity conservation (Talib et al., 2020).

The herpetofauna, comprising the collective group of amphibians (frogs, toads, and caecilians) and reptiles (lizards, snakes, and turtles), is an essential ecological element and a key indicator of environmental health and forest integrity. Their significant sensitivity to microhabitat conditions, a trait that is especially important in complex tropical rainforests, is the source of this bioindicator value (Ibrahim et al., 2012).

Due to their unique biology, amphibians are recognized worldwide as the most vulnerable group of vertebrates. Besides serving as a respiratory organ, their very permeable epidermis makes them highly vulnerable to the absorption of contaminants and chemicals from the environment. They are also highly susceptible to ecosystem fragmentation and microclimatic instability due to their biphasic life cycles, which necessitate both suitable terrestrial conditions for adult stages and pristine aquatic habitats for larval development (Scheele et al., 2019; Quah et al., 2021).

Extensive herpetological research has established the Gunung Inas Forest Reserve (GIFR) as a significant regional hotspot for biodiversity. Notably, research on amphibian populations has revealed a significant level of diversity. Ibrahim et al. (2012) highlighted the existence of habitat-sensitive species, such as *Odorrana hosii*, *Leptolalax gracilis,* and *Limnonectes blythii,* in their compilation of 28 species from six families. Shahrudin et al. (2021) subsequently added 15 additional records and documented an even greater diversity of 41 species comprising seven families, including the endemic anuran *Rentapia flavomaculata*.

The diversity of reptiles has also been thoroughly documented. Within the reserve, Shahrudin et al. (2013) identified six species of freshwater turtles (belonging to three families), 20 species of snakes (belonging to seven families), and 19 species of lizards (belonging to four families). Nine reptile species and eight amphibian species were previously recorded by Grismer et al. (2010), which supports this richness. Additionally, specific ecological interactions have been studied, such as the feeding ecology of species like *Leptobrachium hendricksoni* and *Hylarana cf. labialis* (Hui & Jaafar, 2012).

This study aims to bridge the gap between ecological research and to strengthen the ecotourism value at Sungai Sedim Forest Eco Park. It systematically updated the herpetofauna inventory within the Sungai Sedim Forest Eco Park. Previous studies have established the Gunung Inas Forest Reserve as a biodiversity hotspot. This research provides a targeted and contemporary assessment of the species present specifically within the eco park's boundaries. The core objective is to leverage this new ecological data to strategically promote the integration of herpetofauna into the park's existing ecotourism framework. Currently, tourism in SSFEP primarily focuses on adventure-based activities, such as its canopy walk and water rafting. By scientifically documenting a rich and diverse assemblage of species, this study provides the foundational knowledge to develop new, unique ecotourism products.

2. MATERIALS AND METHODS

2.1. Study area

This study was conducted in Compartment 16 (Figure 1), with a specific focus on the hill dipterocarp level. Geographically, Gunung Inas Forest Reserve is a part of the Banjaran Hijau, the third-largest mountain range in Peninsular Malaysia. It is located in the Baling district of Kedah. The reserve's 37,347 hectares of forest cover feature a diverse range of forest types, including lower montane, higher montane, lowland dipterocarp, and hill dipterocarp forests (Kiew, 1998; Manokaran, 1998).

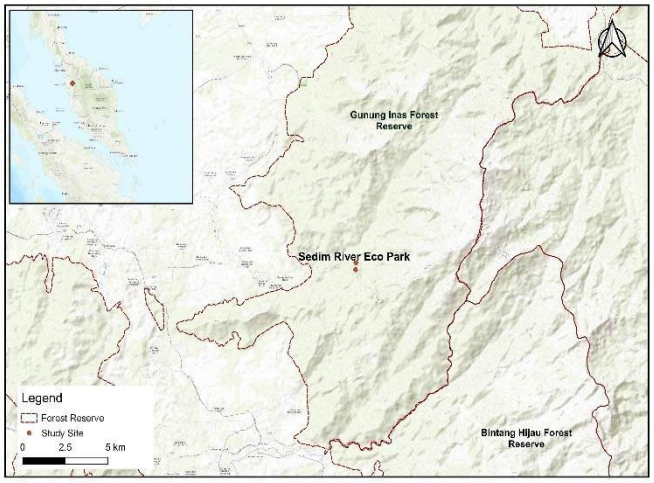

Figure 1: Study site at Gunung Inas Forest Reserve, Kedah

2.2. Herpetofauna trapping

This study consisted of five sampling sessions from July to October 2022. Drift-fenced pitfall traps and visual encounter surveys (VES) were among the primary methodologies employed during the survey, which focused on sampling along the stream and forest trails. We used a Y-shaped drift-fenced pitfall with an 18-litre plastic bucket to collect terrestrial restricted herpetofauna. Three duplicates in all, each with nine plastic buckets buried securely in the ground, had been set out within a 400 m x 200 m plot. Each bucket was drilled at the bottom to allow for adequate drainage. These traps were left open for five consecutive days, with daily monitoring.

Besides trapping, Visual Encounter Surveys (VES) were conducted for three nights in each session, with a minimum effort of two hours, using wide-beam headlights and

torchlights to enhance visibility during nighttime observations. The searches were conducted along the plot trails and in nearby river areas. Specimens were caught by hand or with a snake tong or a snake hook, making it easier to actively search for herpetofauna along forest trails, in arboreal habitats, under rock formations, and in riverine or aquatic areas. Before being examined, amphibian individual that had been apprehended was carefully placed in a temporary plastic bag, while reptiles were placed in a cloth bag.

After the sample was captured and brought back for measurement, identification and photography. Required morphological measurements, such as total length (TL) and snout-vent length (SVL), were taken for reptiles, while only SVL was measured for amphibians. The identification of the species was made by referring to the following sources (Das, 2015; Norhayati, 2017; Das, 2021; Janssen & Sy, 2022). Representative samples of each collected species were photographed for future reference and validation.

Hence, most individuals were released into their natural habitat after the verification process was completed. Nonetheless, a few carefully chosen individuals from each species were kept as voucher specimens. Liver samples were collected and placed in acetone for DNA analysis. Specimens were mounted in 10% formalin and then transferred to 70% denatured ethanol for long-term preservation. Up to three individuals per species were collected as voucher specimens and deposited at the Zoological Collection of the Zoology Branch, Forest Research Institute Malaysia (FRIM). All collection procedures adhered strictly to the animal ethics stipulated by the research permit issued by the Department of Wildlife and National Parks, Peninsular Malaysia (PERHILITAN)..

2.3. Data analysis

To quantify the ecological structure of the studied community, four standard diversity indices were calculated: the Shannon-Wiener Index (H'), the Simpson Index (1-D), Pielou's Species Evenness (J') and Species Richness (S).

The Shannon-Wiener index (H') is a diversity measure based on information theory that takes into consideration both the relative abundance (evenness) and the number of species (richness). It measures the amount of uncertainty in identifying the species of an individual chosen at random from the community. A more diversified community is indicated by a higher (H') value, which is defined by both a higher number of species and a more equal distribution of individuals among those species. The index is a reliable measure for evaluating the general complexity and health of an ecosystem, particularly when the loss of uncommon, low-abundance species is a significant issue, due to its foundation in logarithms, which makes it particularly sensitive to the presence of rare species (Shannon, 2001).

The Simpson Index (1 – D) of diversity calculates the probability that two randomly selected individuals from a sample will be representatives of different species. This index, which provides a reliable inverse measure of community dominance, is significantly influenced by the most dominant species within the community. High diversity (low dominance) is indicated by a value closer to one, whereas low diversity (high dominance) is indicated by a value closer to zero. Compared to the Shannon-Wiener Index (H'), the Simpson Index (1 – D) is less sensitive to uncommon species since it gives more weight to abundant species (Simpson, 1949; Supriatna, 2018).

Independent of species richness, Pielou's Species Evenness (J') is a measure that distinguishes the evenness of species distribution within a community. It is calculated as the ratio of the maximum diversity that may be obtained with the specified species richness to the observed Shannon-Wiener Index (H'). An evenness value of one indicates perfect evenness (all species have the same number of individuals), whereas values closer to zero show that a small number of species dominate the community. The index ranges from zero to one (Pielou, 1966).

The fundamental and easiest measure of diversity is Species Richness (S), which is the total number of distinct species found in each community or study area. By demonstrating the quantity of taxonomic categories present, it provides a simple indicator of the diversity of life. Although species richness is a quantitative measure that ignores the relative abundance of individuals within each species, it is crucial for comprehending the total number of species. Its usefulness in completely characterizing community structure without being linked to an abundance-based index is thus limited, because a community with many uncommon species and one with many common species could generate the same (S) value (Whittaker, 1972).

In ecology, the Species Accumulation Curve (SAC) is a graph that illustrates the relationship between the total number of species recorded and the quantity of sampling effort (e.g., the number of samples, the area studied, or the time spent). Since many new species are being identified during the initial sampling efforts, the curve starts sharply. However, as sampling progresses and fewer new species are discovered, the slope of the curve gradually declines. The SAC serves two primary purposes: first, it determines whether a biodiversity inventory is complete by analyzing when the

curve has started to approach an asymptote (levelling off), which indicates that the majority of species in the area have probably been documented. Secondly, it allows researchers to standardize species richness comparisons between various communities or treatments, ensuring consistent comparisons at the same sampling effort levels. Since SACs are sensitive to sample order, unlike actual rarefaction curves, the average of several random permutations of sample order is usually plotted to produce a smooth, representative curve (Krebs, 1999; Colwell et al., 2012).

3. RESULT AND DISCUSSION

The Sungai Sedim Forest Eco Park herpetofaunal study recorded 43 species from 13 families, revealing a diverse composition. Table 1 provides a comprehensive checklist of all species identified during this study. This result highlights the region's significant contribution to regional biodiversity.

Dicroglossidae (amphibians) family contributed to 16% of all documented species, making them the most species-rich family, according to the familial composition study. Agamidae and Gekkonidae (reptiles), which account for 14% of all species, follow closely. The distribution of species within these families indicates that the research site's terrestrial, arboreal, and riparian microhabitats are well-represented.

The documentation of 14 newly recorded species for the localized inventory of SSFEP is a significant result of this effort. When combined with previous research on the larger GIFR complex (Ibrahim et al., 2012; Grismer et al., 2010; Shahrudin et al., 2013; Shahrudin et al., 2021), this study significantly increases the known biodiversity within the eco park boundaries and raises the revised species richness total for the GIFR complex to 113 species from 21 families. The high microhabitat diversity and structural complexity typical of the lowland and hill dipterocarp ecosystem are highlighted by the ongoing discovery of new records, even in a relatively well-studied forest complex (Talib et al., 2020; Syafiq et al., 2024).

Using both drift-fenced traps and VES, the entire sampling effort was successful in capturing 169 individuals. According to the relative abundance study, the community structure was dominated by seven species, most of which were anurans that were closely linked to aquatic habitats. *Hylarana labialis* (n=17), *Leptobrachium hendricksoni* (n=16), *Amolops larutensis* (n=15), *Limnonectes blythii*, and *Odorrana hosii* each consist of (n=14). In contrast, for reptile *Gonocephalus grandis* (n=10), *Cyrtodactylus consobrinus* and *Cyrtodactylus quadrivirgatus* each consist of (n=8); these are the species that are most commonly found in the study area.

Amolops larutensis has been explicitly recognized as a bioindicator of pristine stream quality. For both adult habitat and larval development, it is totally dependent on fast, clean, uncontaminated, and oxygen-rich forest streams (Ean et al., 2022). These tadpoles of this genus are distinguished by their unique morphology, which includes a modified lower lip that functions as a sucker disc, enabling them to cling to rocks in strong streams (Inger & Stuebing, 2005). The thriving populations of *A. larutensis* and related species, such as *Phrynoidis asper* and *L. blythii*, provide direct biological evidence that the intact hill dipterocarp forest in the area provides essential ecological services, particularly maintaining consistently high-water quality and minimal sedimentation (Ean et al., 2022).

The park's pristine, shallow streams and freshwater swamp forests are consistent with the high abundance of *H. labialis* (Berry & Yong, 1975; Shahriza et al., 2016). Furthermore, the predominance of stream-obligate species such as *O. hosii* and *A. larutensis* indicates that the local habitat conditions, that is, the healthy riparian zones and perennial stream systems, are favourable. The observed structure of herpetofaunal communities is primarily determined by these hydrological circumstances.

Similarly, the stream-dwelling *O. hosii* serves as an environmental sentinel due to its ability to absorb toxins through the skin. As dermal absorption of pollutants affects its health, research has demonstrated that the histology of its skin, particularly the function of mucous and poison glands, plays a part in determining the water quality that it inhabits (Narihan, 2023). The riparian habitat in SSFEP is essentially unaffected and pristine, as evidenced by the co-dominance of *O. hosii* and *A. larutensis* (Ibrahim et al., 2012).

The large bodies of *L. blythii* and *Leptobrachium hendricksoni* further indicate a stable environment with rich leaf litter and healthy riparian zones. These species frequently use isolated stream pools next to the main channel for breeding. The findings from modified environments, where generalist, standing-water species that can withstand higher levels of turbidity and pollution frequently replace stream-breeding specialists, fundamentally differ from the prevalence of these specialists (Syafiq et al., 2024).

The *C. consobrinus* and *C. quadrvirgatus* are often found in association with specific rock formations or decaying logs, suggesting a heterogeneous forest floor. Species that are highly sensitive to site-specific endemism and microhabitat loss are often found in the genus Crytodactylus (Quah et al., 2021). Arboreal species like *G. grandis* and *D. melanopogon* are strong indicators of an intact and structurally sturdy canopy. For example, *G. grandis* is an arboreal species

that is frequently observed climbing to surrounding tree trunks and streamside plants; males can sometimes be discovered lurking up to 15 meters above ground (Grismer, 2011). Their populations are vulnerable to habitat fragmentation, and their continued well-being suggests that the forest structure around the park's infrastructure remains stable.

Table 1: List of Herpetofauna species documented at Gunung Inas Forest Reserve, Kedah

No.	Family	Scientific Name	English Name	IUCN Status
1	Agamidae	*Aphaniotis fusca*	Dusky Earless Agama	LC
1	Agamidae	*Calotes emma*	Forest Crested Lizard	LC
2	Agamidae	*Draco melanopogon*	Black-bearded Gliding Lizard	LC
3	Agamidae	*Gonocephalus bellii*	Bell's Forest Dragon	LC
4	Agamidae	*Gonocephalus grandis*	Great Anglehead Lizard	LC
5	Agamidae	*Gonocephalus liogaster*	Orange-ringed Anglehead Lizard	LC
6	Bufonidae	*Ansonia malayana*	Malaya Stream Toad	LC
7	Bufonidae	*Ingerophrynus parvus*	Lesser Toad	LC
8	Bufonidae	*Phrynoidis asper*	River Toad	LC
9	Colubridae	*Boiga dendrophila*	Mangrove Cat Snake	LC
10	Colubridae	*Gongylosoma longicauda*	Striped Ground Snake	LC
11	Colubridae	*Lycodon effraenis*	Brown Wolf Snake	LC
12	Colubridae	*Lycodon subcinctus*	Malayan Banded Wolf Snake	LC
13	Colubridae	*Oligodon purpurascens*	Brown Kukri Snake	LC
14	Dicroglossidae	*Fejervarya limnocharis*	Field Frog	LC
15	Dicroglossidae	*Limnonectes blythii*	Malayan Giant Frog	LC
16	Dicroglossidae	*Limnonectes deinodon*	Corrugated Frog	LC
17	Dicroglossidae	*Limnonectes utara*	Larut Fanged Frog	LC
18	Dicroglossidae	*Limnonectes malesianus*	Malaysian Peat Frog	LC
19	Dicroglossidae	*Limnonectes plicatellus*	Rhinoceros Frog	LC
20	Dicroglossidae	*Occidozyga martensii*	Rough-touged Floating Frog	LC
21	Dicroglossidae	*Limnonectes deinodon*	Corrugated Frog	LC
22	Elapidae	*Bungarus fasciatus*	Banded Krait	LC
23	Gekkonidae	*Cyrtodactylus consobrinus*	Peter Bent-toed Gecko	LC
24	Gekkonidae	*Cyrtodactylus quadrivirgatus*	Four-lined Bent-toed Gecko	LC
25	Gekkonidae	*Gekko smithii*	Green-eyed Gecko	LC
26	Gekkonidae	*Hemidactylus frenatus*	Flat-tailedHouse Gecko	LC
27	Gekkonidae	*Hemidactylus platyurus*	House gecko	LC
28	Homalopsidae	*Hypsiscopus plumbea*	Boie's Mud Snake	LC
29	Megophryidae	*Leptobrachium hendricksoni*	Red-eyed Spadefoot Toad	LC
30	Megophryidae	*Leptobrachella heteropus*	Malaysian Asian Toad	LC
31	Megophryidae	*Grillitschia longipes*	Long-legged Horned Frog	LC
32	Megophryidae	*Pelobatrachus nasutus*	Malayan Horned Frog	LC
33	Microhylidae	*Microhyla heymonsi*	Dark-sided Chorus Frog	LC
34	Ranidae	*Amolops larutensis*	Larut Sucker Frog	LC
35	Ranidae	*Hylarana labialis*	White-lipped frog	LC
36	Ranidae	*Humerana miopus*	Slashed-back Frog	LC
37	Ranidae	*Hylarana nigrovittata*	Black-striped Frog	LC
38	Ranidae	*Odorrana hosii*	Hose's Frog	LC
39	Rhacophoridae	*Nyctixalus pictus*	Spotted Tree Frog	LC
40	Rhacophoridae	*Polypedates leucomystax*	Four-lined Tree Frog	LC
41	Scincidae	*Dasia grisea*	Brown Tree Skink	LC
42	Scincidae	*Sphenomorphus cyanolaemus*	Blue-throated Skink	LC
43	Viperidae	*Tropidolaemus wagleri*	Wagler's Pit Viper	LC

The study successfully captured the most common and abundant species in the community early on, as evidenced by the first significant increase in the Species Accumulation Curve (SAC) (see Figure 2). Although the curve's flattening towards 40 species is not a true asymptote, it indicates that the study most likely captured the area's predominant population structure. For the majority of species, this suggests an elevated level of sampling completeness. The ongoing, albeit slowing, discovery of new species suggests the existence of uncommon, unidentified, or rare species that are much more difficult to discover. This is a typical occurrence in biodiversity surveys, particularly in highly diverse tropical areas.

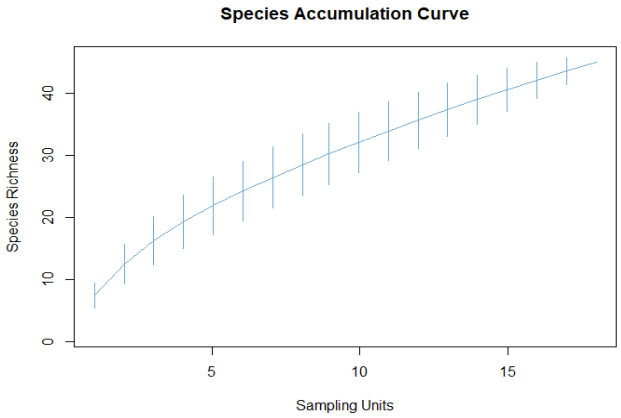

Figure 2: Species accumulation curve (SAC) for Herpetofauna in SSFEP, Kedah

This is demonstrated by a study on the biodiversity of anurans in Taman Negara Johor Endau Rompin (TNJER), a protected area. A larger, long-term sampling over 30 years in the same protected area recorded 52 species, and its SAC did not reach an asymptote, in contrast to a short-term survey nine months in a small plot, which identified 20 species and reached an asymptote for that micro-area (Awang et al., 2017).

The boxplot presents the diversity of species richness (S) recorded during five sampling sessions at SSFEP (Figure 3 – A). Throughout the sampling sessions, the species richness ranged between three to 11 species. The highest number of species was recorded in sampling session 4, while the lowest number of species was recorded in session 2, with only four species. According to Syafiq et al. (2023), many species of lowland snakes in Sekayu Forest, Terengganu, exhibited monthly fluctuations in their occurrence. Mostimportantly, they discovered that for that specific taxon, the rainy season affected the number of captures.

A similar result was shown by Shannon-Wiener Index (H'), with values ranging from 0.75 to 2.25 (Figure 3 – C). The index, which incorporates both species richness and evenness, indicates that the species in the study area are abundant and stable during the sampling period. Ehwan et al. (2022) studied amphibians in Langkawi and showed that it fluctuated across the year, demonstrating that amphibian community diversity is not stable but highly dependent on favorable climatic conditions.

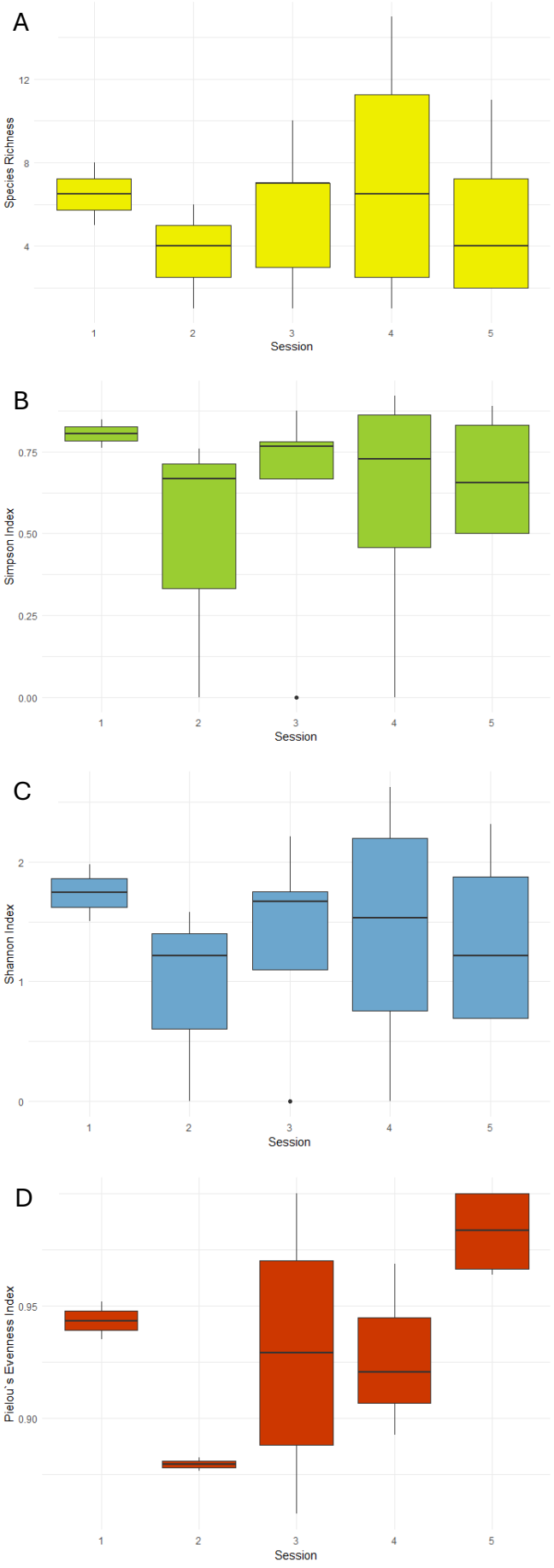

Figure 3: Diversity Index at SSFEP across sessions – A) Species Richness (S), B) Simpson Index (1-D), C) Shannon-Wiener Index (H'), and D) Pielou's Evenness Index (J')

As for the Simpson Index (Figure 3 – B), the results showed that no single or two species were dominant within the habitat. This scenario is supported by Pielou`s Evenness Index (Figure 3 – D), with values ranging from 0.90 to 1.00, indicating that most of the species are evenly distributed and suggesting a stable community structure. Mohd Sazli et al. (2025) concluded that total diversity and stability were enhanced by a high evenness value, which suggested a balanced ecology.

According to the International Union for Conservation of Nature (IUCN), all 44 species documented in this study are classified as Least Concern (LC). While this indicates none are imminently threatened at a global scale, it is crucial to interpret this status with caution. For local conservation management, however, depending only on this global designation is inadequate. Significant local dangers resulting from habitat fragmentation and rapidly shifting environmental conditions are frequently obscured by the Least Concern status (Quah et al., 2021).

The SSFEP herpetofauna community is extremely sensitive to changes brought on by climate change, especially its rheophilic species. Kedah's climate is becoming more unstable, with drier dry seasons increasing the risk of desiccation for breeding pools and wetter wet seasons increasing the risk of flooding, which washes away the tadpoles (Talib et al., 2020).

Therefore, the persistence of this diverse population depends on the continued conservation and protection of their specific microhabitats. In particular, intact forest streams and their associated ecosystems support a diverse range of dominant species. Sensitive species are protected from external heat stress by the intact hill dipterocarp forest, which offers vital microclimatic refugia.

As a result, conservation efforts need to go beyond relying on global status and concentrate on particular, local management measures, such as closely guarding the 20-meter riparian buffer zone (Gomi et al., 2006), to preserve the hydrological and thermal conditions necessary for the survival of stream-obligate species. Hence, reliable and up-to-date baseline inventories generated through locally based surveys are vital for effective conservation planning (Syafiq et al., 2024).

The ecological results confirm SSFEP as an essential ecological sanctuary from the perspective of ecotourism, offering the scientific foundation for a deliberate transition to conservation-oriented ecotourism. These characteristics present significant opportunities for the development of nature-based attractions that go beyond adventure activities. Charismatic and commonly seen species such as *O. hosii* and *A. larutensis* are ideal for introducing visitors to tropical biodiversity. Additionally, the presence of rare species like *Hebius inas*, whose name is derived from the locality, enhances the site's uniqueness and may attract eco-savvy tourists and researchers alike.

The diversity and visibility of amphibian and reptile species, particularly those active at night or near streams, can be used to design guided night walks, bioacoustics tours, and environmental education programs, such as Nature Guides. Visitors can learn about the sounds and life cycles of indicator species, such as *O. hosii*, during guided night walks that focus on streams. The survival of the species is directly linked to the water quality of the streams throughout their journeys. To help visitors understand the detailed ecological linkages, signage and interpretation can highlight species such as *Nyctixalus pictus*, an indicator of old-growth forests, and *D. melanopogon*, a key indicator of canopy health.

The park can foster an atmosphere of conservation responsibility by incorporating visitors into straightforward, long-term monitoring activities, such as recording species sightings using the iNaturalist app or participating in bioacoustics tours (Talib et al., 2020). To ensure the sustainability of wildlife and the economic model, the proceeds from ecotourism should be utilized to support continuous research.

To prevent habitat degradation and behavioural disruption in species-rich areas, define the sensitive zones, especially near rheophilic habitats, and establish strict visitor limits (e.g., no more than eight visitors per guided night walk). To reduce soil compaction and save vital leaf litter and fossorial microhabitats, use elevated boardwalks in high-diversity areas.

4. CONCLUSION

The ecological findings from Sungai Sedim Forest Eco Park's (SSFEP) extensive herpetofauna study offer convincing scientific evidence of the park's remarkable ecological integrity and high biodiversity significance. The presence of an efficient, well-organized community structure, which is currently robust to the limited effects of ecotourism, is confirmed by the observed richness of 44 species, as well as continuously high diversity and evenness indices. As an effective bioindicator, the abundance of stream-dependent species, such as *A. larutensis* and *O. hosii*, confirms the optimal hydrological and temperature conditions maintained by the intact hill dipterocarp forest. The local population stability is highly vulnerable to external threats, such as regional deforestation pressures and synergistic impacts of climate change, even though all species are categorized as Least Concern (LC). Therefore, site-specific, data-driven

management, particularly the strict conservation of riparian buffer zones, must be given top priority in conservation plans. SSFEP has enormous potential to grow its ecotourism offering beyond adventurous recreation and establish itself as a national model for conservation education and sustainable management based on solid biological information when these documented herpetofauna assets are strategically integrated with the park's current scenic and infrastructure value.

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