A CHECKLIST OF FERNS AND LYCOPHYTES FROM MARAI-PARAI IN KINABALU PARK, SABAH

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ABSTRACT

Mount Kinabalu's unique ecosystem supports a high diversity of rare and endemic fern species, yet the species richness of ferns and lycophytes in the Marai-Parai region remains understudied. This research aimed to investigate and document the species richness of ferns and lycophytes in the Marai-Parai area of Kinabalu Park, Sabah. Using existing identification resources and herbarium collections, a total of 62 species from 16 families were identified, including 55 ferns and seven lycophytes. *Oreogrammitis* (six spp.) and *Hymenophyllum* (five spp.) were the most diverse genera, while lycophytes were represented by Lycopodiaceae (five species) and Selaginellaceae (two species). These findings contribute valuable information on fern and lycophyte diversity within the biodiverse Kinabalu Park, aiding conservation efforts by identifying areas of high diversity and potential endemism, and guiding future management strategies.

Keywords: *Borneo, diversity, endemic, Malaysia, pteridophytes*

INTRODUCTION

Ferns and lycophytes are unique types of plants that are distributed worldwide. There are approximately 1,165 species of ferns in Malaysia, with 806 species recorded in Sabah and 645 species found on Mount Kinabalu (Parris and Latiff, 1997; Maideen et al., 2011; Andi et al., 2022). The unique ecosystem of Mount Kinabalu, the highest peak on the island of Borneo and in Southeast Asia, contributed to the highest number of rare and endemic species of ferns. The presence of various climate and vegetation zones within this mountain is the reason why it harbors many species within a small area (Rahbek et al., 2019). Despite numerous studies on ferns on Mt Kinabalu Sabah, but ferns on the western slope of the mountain are poorly understood.

Marai-Parai is known for its rich biodiversity, with a wide variety of plant species, including ferns and lycophytes. These plant groups play a crucial role in maintaining ecological balance and contribute to the overall species richness of the area. Despite their ecological importances, there is yet a comprehensive study of the species richness of ferns and lycophytes in the Marai-Parai region.

The aim of this study was to investigate the species richness of ferns and lycophytes in the Marai-Parai area of Kinabalu Park, Sabah, contributing to our understanding of this unique ecosystem. The primary objective of this study was to assess and document the species richness of ferns and lycophytes in the Marai-Parai region. The findings of this study will provide valuable information to the scientific community on fern and lycophyte diversity within the highly biodiverse Kinabalu Park and will aid in conservation efforts by identifying areas of high diversity and potential endemism, thereby guiding future management strategies.

METHODOLOGY

Marai-Parai is situated at an elevation of approximately 1,500 m on the western slope of Mount Kinabalu (Figure 1). It was named after the extensive coverage of *Costularia pilisepala* (Steud.) J.Kern (Cyperaceae) in the area. This plant is resembling paddy and is referred to as “Marai-Parai” in the Dusun languages. The soils in this region are characterized by their waterlogged and ultramafic composition, which is a result of water percolating from the summit plateau that towers above. This led to peat and soil acidification. The vegetation in this region is dominated by graminoid scrubs (van Der Ent et al., 2018).

Data collection and analysis

This research was undertaken during the Marai-Parai expedition organized by Sabah Parks, which took place from October 10th to October 19, 2023. The data gathered during fieldwork conducted between September 19, and September 21, 2018, were also incorporated. The fern and lycophyte samples were obtained along the trail from the Nunuk Camp to the Kobuturan Camp, situated at an elevation of 2,200 m asl. The specimen collection carried out in 2018 covered the old trails from Tahubang to Marai-Parai.

The present study involved the collection of ferns and lycophytes along designated trails, with two to four duplicates per species being collected. The observation and opportunistic sampling methods were employed following the protocol established by Nitta (2016). The observation was only for common and sterile species that we did not collect. The collected specimens were processed for herbarium collection, following the existing procedure for plant specimen preparation outlined by Alexiades (1996). All collected specimens were subsequently deposited at the Kinabalu Park Herbarium (SNP), located at the Kinabalu Park headquarters, with duplicates at BORNEENSIS herbarium (BORH) of the Institute for Tropical Biology and Conservation (ITBC), UMS, and the Sandakan Herbarium (SAN) at the Forest Research Center (FRC), Sandakan.

Ferns and Lycophytes Identification

The present study utilized existing key identification resources and the most up-to-date taxonomic and floristic information on ferns classification, such as those provided by Holttum (1987, 1991), Piggot et al. (1988), Parris et al. (1992) Beaman and Edward (2007), Beaman and Edwards (2007), Knapp (2011), Chao et al. (2014), and Chen et al. (2022), to confirm species identification at the species level. The taxonomic treatment of ferns and lycophytes adopted in this study followed the work of Christenhusz et al. (2011), Christenhusz and Schneider (2011) and Rothfels et al. (2012). The names of the authors of the taxa are abbreviated in accordance with the standards established by Pichi-Sermolli (1977). In addition, the study refers the websites “Checklist of ferns and lycophytes of the world” to provide the updated classification and naming of the species (Hassler, 1994 – 2024). The study also used comparisons with the fern collection at the herbaria (BORH, SAN, SNP) and online collections available on Global Biodiversity Information Facility (GBIF.org, 2024) and Ferns and Lycophytes of the World (2011 - 2021) to further confirm the identification of the species.

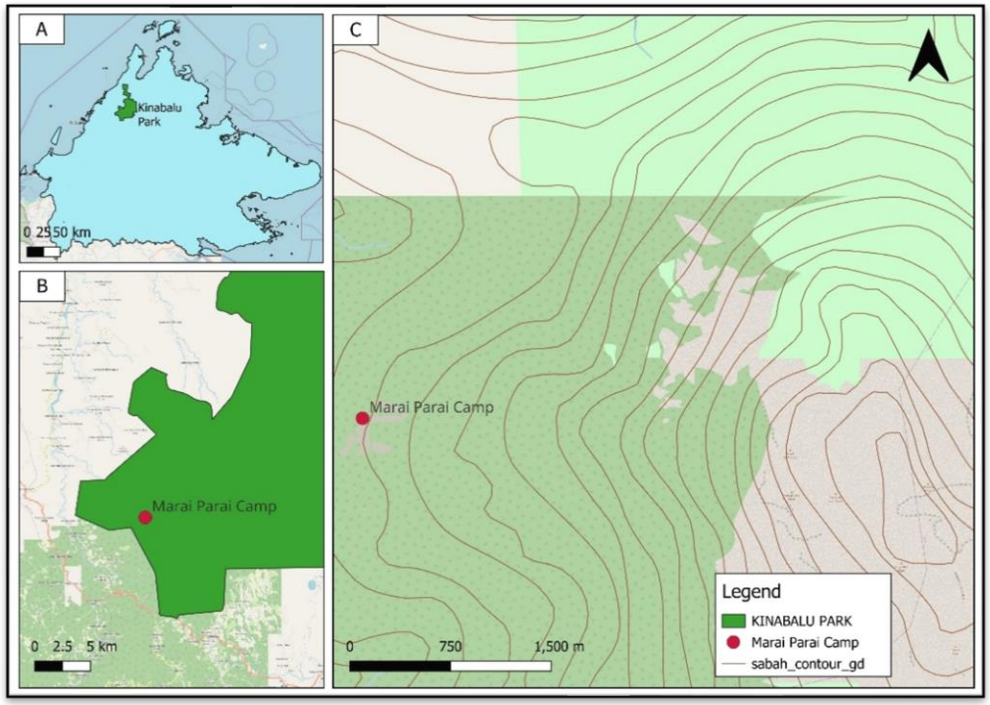

Figure 1. The map shows the study area in Sabah, Malaysia. (A) Kinabalu Park is highlighted within the larger Sabah region. (B) The location of the base camp and study site during the expedition within the Marai-Parai area are indicated. (C) The topographical map of the Marai-Parai and surrounding area, indicating the elevation through contour lines.

RESULTS

In this study, we collected most of the fern's specimens between 1500 m to 2,200 m asl. We identified 62 species from 16 families (Table 1), totalling 98 specimens. These taxa included 55 ferns (Fig. 2) and seven lycophytes (Fig. 3). Among the ferns, Polypodiaceae was the most prominent family with 15 species, followed by Hymenophyllaceae with 11 species. Lindsaeaceae, Cyatheaceae, and Dryopteridaceae also had eight, seven and five species, respectively. The remaining families, Pteridaceae, Davalliaceae, Blechnaceae, Dipteridaceae, Thelypteridaceae, Athyriaceae, Aspleniaceae and Tectariaceae, each only represented by a single species. These families accounted for 9.6% of the ferns found in Kinabalu parks area. The most diverse genera were *Oreogrammitis* (six species) and *Hymenophyllum* (five

species). Lycophytes were represented by only two families: Lycopodiaceae with five species and Selaginellaceae with two species.

Table 1. Checklist of the ferns and lycophytes from the Marai-Parai, Kinabalu Park, Sabah.

Families	Species
LYCOPHYTES	
Lycopodiaceae	*Huperzia javanica* (Sw.) Fraser-Jenk.
	Huperzia serrata (Thunb. ex Murray) Trevis
	Palhinhaea cernua (L.) Vasc. & Franco
	Phlegmariurus phlegmaria (L.) Holub
	Phlegmariurus squarrosus (G. Forst.) Á. Löve & D. Löve
Selaginellaceae	*Chuselaginella alopecuroides* (Baker) Li Bing Zhang & X.M. Zhou
	Kungiselaginella sp.
FERNS	
Aspleniaceae	*Hymenasplenium obscurum* (Blume) Tagawa
Athyriaceae	*Diplazium cordifolium* Blume
Blechnaceae	*Blechnopsis orientalis* (L.) C. Presl
Cyatheaceae	*Alsophila latebrosa* Wall.
	Alsophila longipes (Copel.) R.M. Tryon
	Alsophila sp.
	Gymnosphaera ramispina (Hook.) Copel.
	Sphaeropteris capitata (Copel.) R.M. Tryon
	Sphaeropteris glauca (Blume) R.M. Tryon
	Sphaeropteris sp.
Davalliaceae	*Davallia repens* (L. fil.) Kuhn
Dipteridaceae	*Cheiropleuria bicuspis* (Blume) C. Presl
Dryopteridaceae	*Arachniodes aristata* (G. Forst.) Tindale
	Arachnoides cf. carvifolia (Kunze) Ching
	Dryopteris nodosa (C. Presl) Li Bing Zhang
	Dryopteris pseudocaenopteris (Kunze) Li Bing Zhang
	Elaphoglossum sp.
Hymenophyllaceae	*Abrodictyum obscurum (*Blume) Ebihara & K. Iwats.
	Abrodictyum pluma (Hook.) Ebihara & K. Iwats.
	Abrodictyum sp.
	Crepidomanes sp.1
	Crepidomanes sp.2
	Hymenophyllum edentulum (Bosch) C. Chr.
	Hymenophyllum pallidum (Blume) Ebihara & K. Iwats.
	Hymenophyllum pilosissimum C. Chr.

	Hymenophyllum sp.1
	Hymenophyllum sp. 2
	Vandenboschia maxima (Blume) Copel.
Lindsaeaceae	*Lindsaea cultrata* (Willd.) Sw.
	Lindsaea jamesonioides Baker
	Lindsaea oblanceolata Alderw.
	Lindsaea orbiculata (Lam.) Mett. *ex*-Kuhn
	Lindsaea rigida J. Sm.
	Odontosoria chinensis subsp. *chinensis* (L.) J.Sm.
	Osmolindsaea odorata (Roxb.) Lehtonen & Christenh
	Tapeinidium pinnatum (Cav.) C. Chr.
Lomariopsidaceae	*Cyclopeltis crenata* (Fée) C. Chr.
Polypodiaceae	*Calligrammitis* sp.
	Calymmodon clavifer (Hook.) T. Moore
	Calymmodon gracilis (Fée) Copel.
	Chrysogrammitis sp.
	Dasygrammitis mollicoma (Nees & Blume) Parris
	Oreogrammitis congener (Blume) Parris
	Oreogrammitis reinwardtii (Blume) Parris
	Oreogrammitis reinwardtioides (Copel.) Parris
	Oreogrammitis scabristipes (Baker) Parris
	Oreogrammitis setigera (Blume) T.C. Hsu
	Oreogrammitis subpinnatifida (Blume) Parris & Sundue
	Prosaptia contigua (G. Forst.) C. Presl
	Scleroglossum sulcatum (Mett.) Alderw.
	Selliguea taeniata (Sw.) Parris
	Xiphopterella coriacea Parris
Pteridaceae	*Haplopteris ensiformis* (Sw.) E.H. Crane
Tectariaceae	*Tectaria membranacea* (Hook.) Fraser-Jenk. & Kholia
Thelypteridaceae	*Mesophlebion crassifolium* (Blume) Holttum

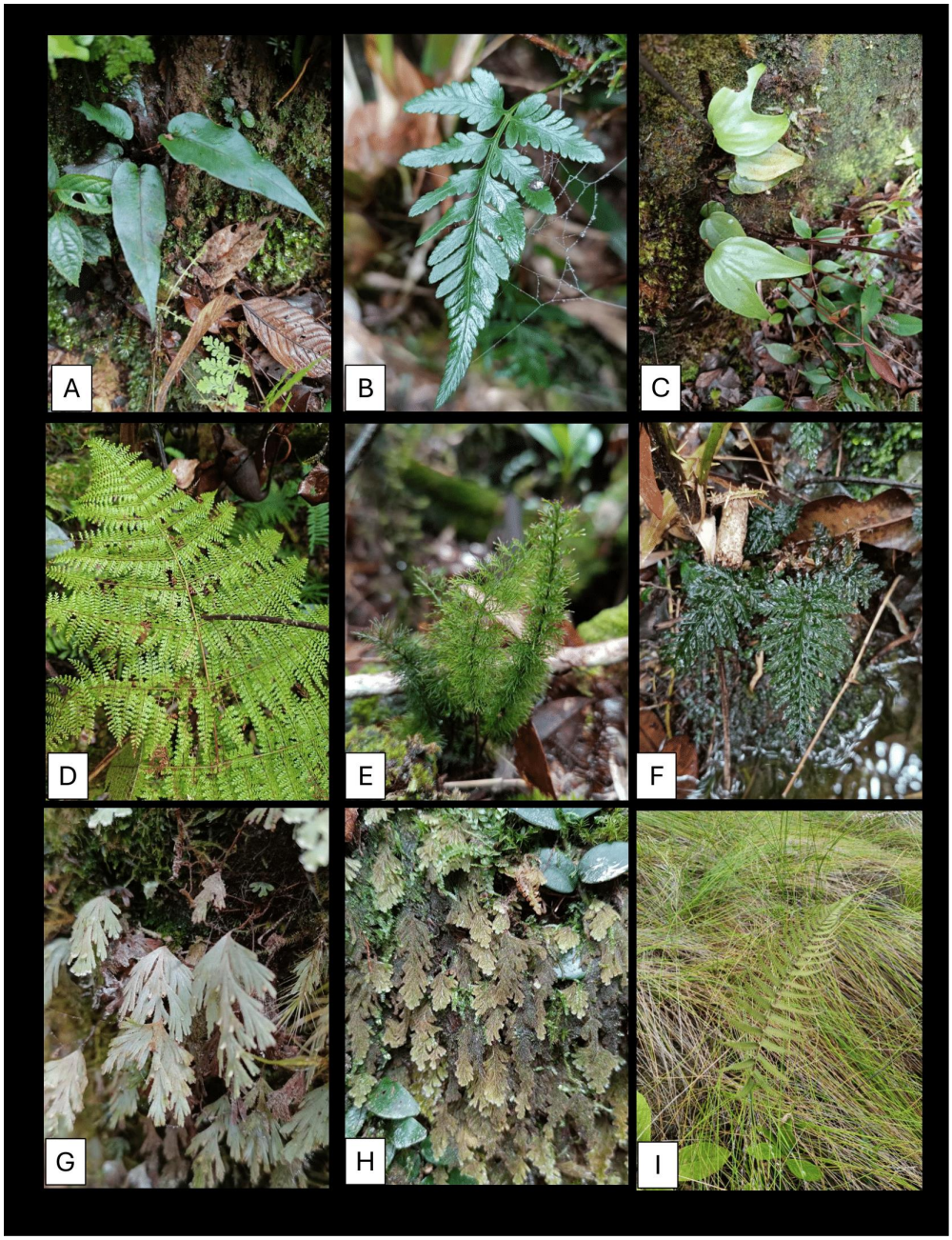

Figure 2. Representative of fern species from Marai-Parai region. A. *Diplazium cordifolium*; B. *Davallia repens*; C. *Cheiropleuria bicuspis*; D. *Dryopteris nodosa* E. *Abrodictyum pluma*; F. *Abrodictyum obscurum;* G. *Hymenophyllum pallidum;* H. *Hymenophyllum pilosissimum;* I. *Mesophlebion crassifolium*.

Figure 3. Representative of lycophyte species from Marai-Parai region. A. *Huperzia javanica*; B. *Huperzia serrata*; C. *Phlegmariurus phlegmaria*; and D. *Phlegmariurus squarrosus*.

DISCUSSION

Previous studies on ferns in tropical mountains have shown that the mid-elevational range, between 1,500 and 2,000 m asl, has the highest fern diversity in terms of both richness and abundance (Bhattarai et al., 2004; Kluge et al., 2006; Kessler et al., 2011). Our results are consistent with those of other studies on the diversity of ferns and lycophytes in the tropical mountains. In our study, species richness was found to be higher between 1,500 and 2,200 m asl. The species richness and diversity of ferns are influenced by environmental factors such as humidity, water availability and air temperature. It is well established that fern diversity patterns are closely linked to climatic conditions, with both regional and local fern diversity peaking in habitats with moderate temperatures, high precipitation and high humidity (Kessler et al., 2011; Weigand et al., 2020). Low temperatures and humid conditions are the most suitable conditions for ferns to survive. Kessler et al. (2011) found that the maximum richness of ferns along elevational gradients in tropical wet environments is located at around 15 – 7°C, mean annual temperature.

In this study high species richness within Polypodiaceae and Hymenophyllaceae was recorded. This finding suggests that these families are particularly well-adapted to the environmental conditions in Marai-Parai region. Studies conducted by William-Linera et al. (2005) indicate that *Hymenophyllum* flourish in the specific conditions present in cloud forest fragments, which provide suitable microclimates and topographic diversity. The abundance of Hymenophyllaceae and Polypodiaceae in montane tropical forests is also due to their adaptability to varying altitude (Mehltreter, 1996). *Hymenophyllum* lack cuticles and stomata, making them dependent on humid microhabitats (Krömer et al., 2006). They thrive in montane forests due to reasonably frequent precipitation and low evaporation, which are natural features of these environments.

Polypodiaceae and Hymenophyllaceae, as exemplified by the genera *Oreogrammitis* and *Hymenophyllum*, are predominantly epiphytic fern families. A study conducted in Volcán Maderas, Nicaragua revealed a peak in species richness at 1000 m asl, with epiphyte abundance increasing with elevation (Berrios et al., 2022). This mid-elevation rise in distribution is a common pattern for epiphytic ferns in tropical montane areas, indicating that their abundance is highest at intermediate elevations. Research conducted in tropical areas has also shown that epiphytic ferns can be found at elevations as high as 4500 meters above sea level (Zotz and Zotz, 2016).

The findings of this study indicate that the records of Lycophytes species in terms of species richness are inadequate. Only two species of Selaginellaceae and five species of Lycopodiaceae are reported. However, based on our observations, the abundance of *Kungiselaginella* sp. was high at 1,800 m asl. The predicted elevation range for *Selaginella* is 0–2,500 m asl in Java, Indonesia, as reported by Setyawan et al. (2020). This genus is typically found in high-altitude ecosystems with humid and cool climates. Nonetheless, there is a lack of studies specific to lycophytes, which limits our understanding of the elevation range of lycophytes. There is no specific information available regarding the elevation range of lycophytes in any recent paper, especially in the tropics.

The primary limitation of this study was the accessibility of the area and sampling time. During the fieldwork expedition, we only had three days to collect and record fern specimens, and unfavourable weather prevented us from collecting more specimens. In addition, the only accessible location for collecting specimens was along the main trail from the Nunuk camp to the Kobuturan campsite, as the topography within 5 m of the main trail was mostly inaccessible and steep.

CONCLUSION

In conclusion, this study revealed a moderate diversity of fern and lycophyte species in the Marai-Parai area of Kinabalu Park, particularly dominated by epiphytic ferns, highlighting the unique ecological characteristics of this region compared to other areas with higher fern diversity. However, the limited accessibility and sampling time restricted the scope of the study, emphasizing the need for further research to fully understand fern and lycophyte diversity in this unique ecosystem, especially for lycophytes.

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