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Floristic Diversity of Pteridophytes in the Rocky Outcrops of Kumarapuram-Thoppur, Kanniyakumari District, Tamil Nadu, India

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Abstract

A taxonomic study was conducted to document the diversity of pteridophytes in the rocky outcrops of Kumarapuram-Thoppur, Kanniyakumari District, Tamil Nadu, located within the Southern Western Ghats. A total of 20 species, representing 15 genera and 9 families, were recorded. The dominant family was Pteridaceae (6 species), followed by Aspleniaceae and Ophioglossaceae (3 species each). Other families, such as Salviniaceae and Polypodiaceae, contained 2 species each, while Isoetaceae**,** Schizaceae, Marsileaceaeand Selaginellaceae were monospecific. Habitat-wise, terrestrial species were the most abundant (8 species), followed by aquatic and lithophytic (5 each), and epiphytic (2) species. The findings highlight the significant ecological diversity of pteridophytes in this region, with a predominance of species adapted to rocky and aquatic environments. This diversity is threatened by anthropogenic disturbances, particularly mining, which may impact the delicate balance of these ecosystems. Further conservation efforts are essential to protect this unique flora.

Key words: Pteridophytes; Diversity; Rocky Outcrops; Southern Western Ghats; Anthropogenic Disturbance

Introduction

Pteridophytes, which include ferns, horsetails, and club mosses, are among the oldest groups of vascular plants, playing crucial ecological roles in forest ecosystems, such as soil stabilization, moisture retention, and nutrient cycling (Perry et al., 2011). The diversity and distribution of pteridophytes are shaped by a range of ecological factors, including temperature, humidity, substrate type, and microhabitat conditions (Kaur and Sharma, 2019). In particular, rocky outcrops provide a distinctive habitat for pteridophytes, offering stable microclimates and often serving as refugia for species that may be sensitive to other environmental changes (Raghunathan et al., 2017).

The Southern Western Ghats, a region rich in biodiversity, have been identified as one of the world's biodiversity hotspots. This area, including the Kanniyakumari District of Tamil Nadu, is home to a wide variety of flora and fauna, including a significant number of pteridophyte species. Kanniyakumari District, located at the southernmost tip of India, represents a transition zone between the Western Ghats and the coastal plains, resulting in a unique

combination of climatic and ecological conditions that support diverse plant communities, including a rich fern flora (Nayar and Sastry, 1987). The district's varied topography—characterized by steep hills, valleys, and rocky outcrops—further enhances the diversity of pteridophyte species, with different ecological niches supporting both terrestrial and epiphytic ferns.

Several studies have documented the pteridophyte flora of Tamil Nadu, including the Western Ghats and Kanniyakumari District. Nayar and Sastry (1987) provided a comprehensive account of the pteridophytes in the region, highlighting the diversity of fern species and their role in maintaining ecological balance. In the specific context of Kanniyakumari, Manickam and Nair (2010) reported on the occurrence of several fern species in the district, noting the presence of both endemic and common species in the moist forest ecosystems of the area. Other regional studies by Pullaiah and Narasimhan (2006) and Velayudhan (2010) have noted the presence of specialized pteridophyte species in various habitat types across Tamil Nadu, including rocky outcrops and forest margins. However, there has been limited attention paid to the specific diversity of pteridophytes in the rocky outcrops of Kumarapuram-Thoppur in Kanniyakumari District, an area that provides an interesting contrast in terms of habitat conditions and anthropogenic pressures.

The rocky outcrops of Kumarapuram-Thoppur represent unique microhabitats that support specialized fern species due to their particular hydrological and thermal conditions. However, these ecosystems are increasingly subjected to anthropogenic disturbances, particularly from mining activities. Abandoned mines in the area have led to the extraction of rock from certain outcrop sites, resulting in the loss of natural habitats and the degradation of the surrounding environment. Such disturbances often have profound impacts on the local flora, including pteridophytes, as they may alter the microclimate, reduce substrate availability, and change soil composition, thereby affecting the growth and survival of species (Singh and Kaur, 2014). Furthermore, mining activities can introduce invasive species, further threatening the native fern flora (Chauhan et al., 2013).

Despite these concerns, the potential for pteridophyte species to persist in disturbed or modified habitats remains an area of interest for ecological research. The ability of some fern species to regenerate and thrive in disturbed environments, particularly in rocky outcrops where conditions can remain relatively stable, warrants further exploration. Previous studies on fern diversity in disturbed environments (such as mining sites) have indicated that while some species may be highly sensitive to such disturbances, others may exhibit resilience, provided that specific ecological conditions (e.g., moisture availability and soil pH) are maintained (Ravikumar and Velayutham, 2000).

In light of these factors, the present study aims to document the pteridophyte diversity in the rocky outcrops of Kumarapuram-Thoppur, Kanniyakumari District, with particular focus on understanding the impact of anthropogenic disturbances, including mining, on the composition and distribution of species. By surveying the pteridophytes in both undisturbed and disturbed sites, this research will provide insights into the ecological resilience of these species, and contribute to the broader understanding of the role of human activities in shaping

the biodiversity of tropical ecosystems. Furthermore, the study will assess the conservation status of the fern species in the area, which could inform local conservation efforts aimed at preserving these unique and sensitive habitats.

Materials and Methods

Study Area and Climate

The study was conducted in Kumarapuram-Thoppur village (8.1769° N, 77.5053° E), located in Kanniyakumari District, Tamil Nadu, within the Southern Western Ghats. This region, encompassing an area of approximately 10 km², includes the Subramania Swamy Temple situated atop a rocky outcrop. The local climate is warm and humid, with temperatures ranging from 25°C to 30°C, and high humidity levels, particularly during the southwest monsoon.

Field Survey and Specimen Collection

Field surveys were carried out between mid-December and mid-March, focusing on pteridophytes during their reproductive stages. Specimens were collected from a variety of microhabitats, including terrestrial, epiphytic, lithophytic, and hydrophytic forms. The plants were carefully observed for diagnostic features, and relevant field notes were made on fresh materials. All specimens were pressed and mounted on standard herbarium sheets for further analysis.

Taxonomic Identification

Identification of the pteridophytes was performed by consulting taxonomic literature, including Pteridophytic Flora of Western Ghats by Manickam and Irudayaraj (1992; 2003). Diagnostic characters of each specimen were examined to ensure accurate classification. The identified specimens were deposited at the Herbarium of Nesamony Memorial Christian College, Marthandam, for future reference and verification.

Systematic Literature Review on Medicinal Plants

A systematic search was conducted to identify peer-reviewed publications on the medicinal properties of pteridophytes. Key terms such as "pteridophytes," "useful parts," "medicinal applications," and "treatment of ailments" were used to search across five major databases: ScienceDirect, PubMed Central, MEDLINE, Google Scholar, and authoritative governmental sources, including the World Health Organization, FDA, and CDC. Only peer-reviewed articles containing these key terms were selected for review.

Results and Discussion

A total of 20 species of pteridophytes, representing 15 genera and 9 families, were recorded from the rocky outcrops of Kumarapuram-Thoppur, Kanniyakumari District (Table 1). The

floristic composition reveals a diverse assemblage of ferns, with notable dominance in certain families and life forms.

Family Composition

The family Pteridaceae was the most species-rich, comprising 6 species, which is consistent with the prominence of this family in many tropical and subtropical regions (Chauhan et al., 2013). This family, known for its adaptability to a wide range of habitats, is particularly abundant in disturbed environments, including rocky outcrops, where species such as Pteris and Adiantum thrive (Raghunathan et al., 2017).

The families Aspleniaceae and Ophioglossaceae each contributed 3 species, which is also in line with findings from other studies that highlight the diversity of these families in tropical ecosystems (Manickam and Irudayaraj, 1992). Aspleniaceae, known for species like Asplenium and Neottopteris, typically prefers humid, shaded environments, often found in crevices of rocks or under canopy cover (Ravikumar and Velayutham, 2000). Ophioglossaceae, comprising species such as Ophioglossum, is notable for its unique reproductive strategy and preference for nutrient-poor soils, making it an interesting family in terms of ecological adaptation.

The Salviniaceae and Polypodiaceae families each accounted for 2 species, reflecting the widespread distribution of these families in wetlands and moist environments (Velayudhan, 2010). Salviniaceae species, such as Salvinia and Azolla, are typically aquatic, with adaptations to floating on water bodies, while Polypodiaceae species are commonly found on tree trunks, rock faces, and shaded areas in moist forests.

Three families—Isoetaceae, Schizaceae, Marsileaceaeand Selaginellaceae - were monospecific, with each family represented by a single species. The occurrence of monospecific families in this region underscores the ecological specificity of certain pteridophytes. For instance, Isoetes (Isoetaceae) is an aquatic genus, often found in shallow freshwater bodies, while Schizaea (Schizaceae) Marsilea (Marsileaceae) and Selaginella (Selaginellaceae) are both associated with wetland habitats, including ephemeral ponds and marshes. The monospecific nature of these families is indicative of their specialized habitat requirements and underscores the importance of these ecosystems in maintaining such species (Singh and Kaur, 2014).

Life-Form Composition

The life-form distribution of the recorded pteridophytes reveals a clear dominance of terrestrial species, with 8 species occupying this ecological niche (Figure 1). This is a common pattern in the Western Ghats, where terrestrial ferns tend to dominate the ground layer of tropical forests and rocky outcrops (Pullaiah and Narasimhan, 2006). Terrestrial pteridophytes, such as Adiantum and Pteris, are well-adapted to the rocky, often nutrient-poor soils found in the study area, thriving in crevices and on exposed rock faces, where moisture availability and microclimatic conditions are crucial for their growth.

Aquatic species (5 species) were the second most common life-form, which is consistent with the humid and wet conditions characteristic of the area, particularly during the southwest monsoon. Ferns such as Azolla (Salviniaceae) and Marsilea (Marsileaceae) are typically found in stagnant or slow-moving water, where they contribute to the aquatic biodiversity and may have roles in water purification and nutrient cycling (Raghunathan et al., 2017). The presence of these species indicates that the study area includes not only terrestrial and epiphytic habitats but also wetlands or temporary pools that support aquatic ferns.

Lithophytic ferns (5 species), which grow on rocks or in rock crevices, were also relatively abundant. Lithophytes are typically found in areas where other forms of vegetation may struggle to establish, such as rocky outcrops and steep slopes. These ferns, such as Lepisorus and Asplenium, are adapted to survive in harsh conditions with limited soil and high exposure to the elements, demonstrating remarkable resilience to environmental stress (Chauhan et al., 2013). The presence of lithophytic ferns in rocky outcrops is a common ecological feature in the Western Ghats and other similar habitats (Velayudhan, 2010).

Lastly, epiphytic ferns (2 species) were recorded, though they were less common compared to other life forms. Epiphytic ferns, such as Drynaria and Polypodium, grow on trees and other vegetation, drawing nutrients and moisture from the air and surrounding environment. These ferns are often found in humid, forested habitats, where they benefit from the microclimatic conditions created by the canopy and the availability of organic matter (Ravikumar and Velayutham, 2000). Their presence in the study area highlights the complex interactions between forest structure, humidity, and the fern species that thrive in the canopy.

Ecological Implications

The results from this study highlight the diverse range of pteridophyte life-forms and their ecological roles in the Kumarapuram-Thoppur area. Terrestrial species dominate due to the availability of suitable substrate in rocky outcrops and the general climatic conditions, but the presence of aquatic and lithophytic species suggests that microhabitats, such as moist rock crevices and temporary water bodies, play important roles in supporting pteridophyte diversity. The epiphytic species further underline the diversity of niches available in the ecosystem, especially in areas with a more developed canopy.

The relative abundance of aquatic and lithophytic species in addition to terrestrial forms may indicate the importance of seasonal changes, such as the monsoon, in shaping the local fern community structure. The adaptation of these species to specific ecological niches also highlights the need for continued conservation efforts, especially considering the anthropogenic disturbances in the area, such as mining activities and land-use changes, which could impact the habitat quality and species composition of these unique ecosystems.

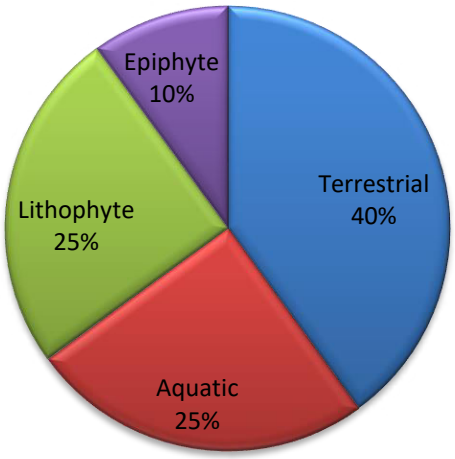

Figure 1. Habitat-wise distribution of pteridophytes in the study area.

Medicinal Uses

The pteridophytes recorded in the present study from the rocky outcrops of Kumarapuram-Thoppur, Kanniyakumari District, exhibit a remarkable range of medicinal properties. These plants, traditionally known for their therapeutic potential, have been documented to treat a variety of ailments, including antimicrobial, anti-inflammatory, anti-dysenteric, hyperglycemic, and hepatoprotective activities. The medicinal uses of pteridophytes are well-established in several ethnobotanical studies, and their bioactive compounds continue to be of significant interest for pharmacological research.

Antimicrobial and Anti-inflammatory Properties

Many pteridophytes are recognized for their antimicrobial and anti-inflammatory properties, which have been documented in several species recorded in the present study. For instance, species of the genus Adiantum (Pteridaceae), such as Adiantum capillus-veneris, have been traditionally used to treat respiratory infections and skin disorders (Velayudhan, 2010). Several studies have reported that extracts from Adiantum species possess significant antimicrobial activity, particularly against Gram-positive bacteria and fungi (Ravikumar and Velayutham, 2000). Similarly, Pteris species, common in rocky outcrops, are known to exhibit anti-inflammatory effects, which may be attributed to compounds like flavonoids and tannins (Manickam and Irudayaraj, 1992). The antimicrobial and anti-inflammatory properties of these species suggest their potential as sources for developing therapeutic agents for infections and inflammatory conditions.

Conclusion

The taxonomic survey of pteridophytes in Kumarapuram-Thoppur reveals a diverse community of 20 species, with a clear dominance of terrestrial life-forms and significant representation of aquatic and lithophytic species. The findings underscore the ecological diversity of the region, with various fern species adapted to distinct habitats, from rocky outcrops to wetlands. This biodiversity, however, is vulnerable to ongoing anthropogenic

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pressures, and conservation efforts are critical to preserve the integrity of these fragile ecosystems. Further studies could focus on the impact of human disturbance on pteridophyte diversity and the potential for conservation through habitat restoration and protection.

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Table 1. Ethnomedicinalpteridophytesof the study area

Sl. No.	Botanical Name	Family	Common Name	Habit	Part used	Ethnobotanical significance	Reference
1	Actinopterisradiata (Sw.) Link.	Pteridaceae	Eyelash Fern.	Lithophytic	Whole plant	Anti-Nephrotoxic	Kumar et al., 2023
2	Adiantumlatifolium Lam.	Pteridaceae	Maidenhair	Terrestrial	Whole plant	Antimicrobial	Siddique et al.,2023
3	Azollapinnata R. Br.	Salviniaceae	Mosquito fern	Aquatic	Whole plant	Antioxidant, Anti-inflammatory, and Anti-apoptotic	Elrasoul, et al.,2020
4	Cerotopteristhalictroides (L.) Brongn.	Pteridaceae	Watersprite	Aquatic	Whole plant	Antibacterial Activity	Beheraet al.,2022
5	Drynariaquercifolia (L.) J. Sm.	Polypodiaceae	Oak leaf fern or basket fern:	Epiphytic	Rhizome	Phytochemical and Pharmacological	Sujinet al.,2021
6	Hemionitis opposita (Kaulf.) Christenh.	Pteridaceae	Heart Fern	Terrestrial	Whole Plant	Anti-parasitic	Kalpanaet al., 2015
7	Hemionitisarifolia (Burm. F.) T. Moore	Pteridaceae	Heart Fern,	Lithophytic	Whole plant	Antidysenteric	Sukumaranet al., 2021
8	IsoetuscoromandelinaL.f.	Isoetaceae	Quillwort	Aquatic	Whole Plant	Hepatoproductive	Begum et al.,2016
9	Lygodiummicrophyllum (Cav.)	Schizaeaceae	Snake fern		Whole	Anti-	Alamet al., 2021

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	R. Br.				Plant	inflammatory	
10	Marsileaminuta L.	Marsileaceae	Dwarf water clover	Aquatic	Leaves	antioxidant	Arokiyarajet al.,2018
11	OphioglossumgramineumWilld.	Ophioglossaceae	Adder's-tongue fern	Terrestrial	Whole plant and rhizome.	Antimicrobial	Benjamin and Manickam, 2007
12	Ophioglossumreticulatum L.	Ophioglossaceae	Netted adder's-tongue fern,	Terrestrial	Whole plant	Anti-inflammatory	Begum et al.,2016
13	Ophioglossumvulgatum L. f.	Ophioglossaceae	Adder's-tongue fern,	Terrestrial	Leaves and Rhizome	Antidiarrheal	Zhang et al.,2020
14	Phlebodiumaureum (L.) J. Sm.	Polypodiaceae	Blue star fern	Epiphytic	Rhizome	Cytotoxic	Marimuthuet al., 2021
15	Pterisvitata L.	Pteridaceae	Chinese ladder brake fern	Lithophytic	Whole plant	Anti-inflammatory	Paulet al ., 2020
16	Salvinia molesta D. Mitch.	Salviniaceae	Kariba weed	Aquatic	Whole plant	Antimicrobial	Mithrajaet al.,2011
17	Selagineall wightii Hieron	Selaginellaceae	Spikemosses	Lithophytic	Whole plant	Antimicrobial	Setyawan, 2009
18	Thelypteris dentata (Forssk.) E.P.St.John	Aspleniaceae	Downy maiden fern	Lithophytic	Leaves	Antimicrobial	Manhas et al., 2018
19	Thelypteris interrupta (Willd.) K.Iwats.	Aspleniaceae	Hottentot fern or Willdenow's fern:	Terrestrial	Rhizome	Antioxidant	Mitra et al., 2019

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20	Thelypteris parasitica (L.) Tardieu	Aspleniaceae	Parasitic maiden fern.	Terrestrial	Leaves and Rhizome	Antimicrobial	Paulraj et al., 2011

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