FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 9 No. 10, October, 2025, pp 181 – 186
DOI: https://doi.org/10.33003/fjs-2025-0910-4068

DISTRIBUTION AND SIMILARITY COEFFICIENTS OF FERNS AND ALLIES IN THREATENED WETLANDS OF SOUTHERN AKWA IBOM STATE-NIGERIA

***[1]Mbong, Emem Okon, [1]Chukwudi, Peter and [2]Konyeme, Thelma E.**

[1]Department of Biology and Forensic Science, Faculty of Science, Admiralty University of Nigeria, Ibusa-Ogwashi Uku, Delta State, Nigeria.
[2]Department of Plant Science and Biotechnology, Faculty of Sciences, University of Delta, Agbor, Delta State, Nigeria.

*Corresponding authors' email: mbongemem@yahoo.com

ABSTRACT

This study assessed the composition, distribution, and ecological similarity of ferns and fern allies across seven threatened wetlands within Eket Local Government Area, Akwa Ibom State, Nigeria using systematic sampling method. Visual inspection, taxa identification and direct counting procedure were employed to evaluate wetland vegetation. The results revealed 17 species from fifteen genera, representing 12 families. Species encountered included *Asplenium sandersonii, Cyclosorus interruptus, Diplazium esculentum, Gleichinia linearis, Lycopodium clavatum, Lygodium microphyllum, Lygodium smithianum, Microgramma owariensis, Nephrolepsis bisserata, Oleandra distenta, Pityrogramma calomelanos, Platycerium stemaria, Pteridium aquilinum, Pteris* sp., *Phymatosorus scolopendria,* and *Sellaginella krausiana.* Etebi and Ikot Udota wetlands each, had 10 species, whereas Atabong and Idim afia wetlands each, had 4 and 2 species, respectively. *Cyclosorus interuptus* and *Nephrolepsis bisserata* were common to all studied locations. Sorenson and Jaccard similarity indices revealed floristic overlap between some sites, with Ikot Usoekong and Ataobong (0.800 and 0.6667, respectively) being the most similar, and Etebi and Ikot Udota (0.3177 and 0.1875, respectively) the most dissimilar. Cluster analysis grouped sites into three major clusters, corresponding with disturbance gradients (roadside versus interior wetlands). Species diversity was notably higher in less disturbed wetlands, indicating that anthropogenic influence was a strong determinant of species composition. The findings highlight the ecological importance of ferns in wetland systems and their potential role in conservation monitoring. This study provides vital baseline data for future ecological assessments, conservation planning, and habitat restoration strategies targeting wetlands and their cryptogamic flora in Southern Nigeria.

Keywords: Ferns, Fern allies, Wetlands, Species Distribution, Floristic Similarity, Bioindicators

INTRODUCTION

Wetlands are ecologically diverse and economically useful ecosystems globally, characterized by the presence of hydric soils, water-saturated conditions, and a specialized assemblage of hydrophytes that thrive under such conditions (Mitsch and Gosselink, 2000; Ogbemudia *et al.,* 2025). They occur as intermediate ecosystems, lying between core terrestrial and aquatic systems, serving as ecological buffers and biodiversity reservoirs. They provide numerous ecosystem services such as flood attenuation, groundwater recharge, climate regulation, pollutant filtration, and carbon sequestration (Ehrenfeld, 2000; Erwin, 2009; Onyegbule *et al.,* 2025). Beyond these biophysical functions, wetlands support complex food webs and harbor diverse flora and fauna, many of which are endemic or threatened.

All over the tropics, wetlands contribute significantly to socio-economic wellbeing, particularly among rural and peri-urban populations that rely on these landscapes for food, fuel, forage, traditional medicine, and cultural practices (Owor *et al*., 2007; Adam *et al*., 2010). However, despite their evident ecological and socio-economic importance, wetlands are among the most threatened ecosystems globally. In Nigeria, and particularly in the Niger Delta region, wetlands face increasing anthropogenic pressures including land conversion, urban expansion, infrastructure development, unregulated resource extraction, and pollution (Mbong *et al.,* 2020; Anwana *et al*., 2020). These disturbances lead to significant habitat fragmentation, species loss, and overall degradation of ecological integrity.

One overlooked component of wetland vegetation in ecological monitoring is the Pteridophyte flora (ferns and their allies) yet they represent a crucial link in plant evolution as seedless vascular plants with distinct sporophytic and gametophytic generations (Mbong *et al.* 2023; Bassey *et al.,* 2024). They perform critical ecological roles in nutrient cycling, succession, soil stabilization, and microclimatic regulation (Srivastava, 2007; Benjamin and Manickam, 2007). Moreover, their sensitivity to microenvironmental changes makes them excellent bioindicators of habitat disturbance and ecosystem health (Winter and Amoroso, 2003; Oloyede *et al.*, 2013).

Despite their ecological significance, ferns remain under-represented in most vegetation and biodiversity studies in Nigeria, particularly in wetland ecosystems. Previous botanical surveys in southern Nigeria have focused largely on angiosperms, with limited attention given to cryptogamic plants (Akomolafe and Sulaimon, 2018). Consequently, there exists a critical knowledge gap regarding the distribution, abundance, habitat preferences, and conservation status of Pteridophytes in these transitional landscapes. This lack of data impedes effective conservation planning, especially in the face of accelerating anthropogenic pressure on wetlands (Mbong *et al.,* 2025).

This study seeks to address this knowledge gap by conducting a comprehensive floristic assessment of ferns and fern allies across selected threatened wetlands in southern Akwa Ibom State, Nigeria. Specifically, the study aims to document the species composition, evaluate patterns of distribution, and determine the similarity coefficients between different wetland sites using standard ecological indices. By doing so, it provides baseline data necessary for monitoring changes in wetland floristic integrity and guiding conservation interventions. In light of the alarming pace of wetland degradation and species erosion, this research is both timely and essential. It highlights the urgent need for integrated conservation approaches that include all taxonomic groups, especially under-studied ones like pteridophytes, to ensure the resilience and sustainability of wetland ecosystems in Nigeria.

MATERIALS AND METHODS

Study Area

The study was carried out in the southern part of Akwa Ibom State, Nigeria—specifically within the Niger Delta wetland belt, a region renowned for its ecological richness and socio-economic importance. The area experiences a humid tropical climate characterized by a bimodal rainfall pattern and distinct wet and dry seasons. Annual rainfall ranges from 2,000 to 3,500 mm, and average annual temperatures hover between 25°C and 32°C (Mbong et al., 2020). Relative humidity remains consistently high, often exceeding 80%, fostering luxuriant plant growth and the development of wetland microhabitats (Onyegbule *et al.*, 2025). Seven wetland sites were selected based on accessibility, ecological relevance, and anthropogenic pressure. These included Asiok, Ataobong, Ikot Udota, Etebi, Ikot Usoekong, Marina, and Idim Afia wetlands. Geographical coordinates were determined using handheld GPS devices to ensure spatial accuracy as follows:

Table 1: Coordinates of Studied Wetlands

Site	Latitude	Longitude	Location
Asiok	7°59’21”E	4°38’44”N	Roadside
Atabong	7 °55’31”E	4° 39’32”N	Roadside
Ikot Udota	7° 58’37”E	4°39’23”N	RoadSide
Etebi	7°:58’41”E	4°39’09” N	Interior
Ikot Usoekong	7°59’16“E	4 °41’04”N	Roadside
Marina	7°55’48”E	4°:37’21”N	Interior
Idim Afia	7° 58’15”E	4°37’21”N	Roadside

These selected wetlands encompassed both roadside and interior habitats, which allowed for comparison of floristic patterns across disturbance gradients. The locations varied in proximity to human settlements, industrial activities, and road networks, thereby offering a representative snapshot of anthropogenic impacts on wetland vegetation.

Vegetation Sampling and Data Collection

A systematic sampling technique was employed to ensure standardized data collection across all sites. At each wetland, a transect line of 25 meters was laid perpendicular to the water body. Along each transect, sampling plots (quadrats) of 1 m × 1 m were established at 5-meter intervals, resulting in five quadrats per site according to the methods of Ogbemudia et al. (2014) and Mbong, *et al.* (2025). Within each quadrat, all ferns and fern-ally species were identified, counted, and their growth habits recorded (erect, epiphytic, climbing, creeping, or lithophytic). Distribution of species was judged using a Four Points scale of Abundant (+++); Common (++); Rare (+); Absent (-).

Plant Identification

Plant identification was conducted in situ using field guides and dichotomous keys, including Dalziel (1937), Hutchinson and Dalziel (1946), and Akobundu and Agyakwa (1998).Where identification was uncertain, specimens were collected, pressed, and taken to a herbarium for further verification. Nomenclature followed the PPG I (2016) classification system to maintain taxonomic consistency.

Data Analysis

Species richness, abundance, and frequency were computed for each wetland. Analysis of Variance (ANOVA) was used to test for significant differences in species abundance among sites, following the methods of Ubom (2006) and Ezekiel *et al.* (2024). Floristic similarities among wetlands were assessed using Jaccard's and Sorenson’s similarity indices, calculated using the presence–absence matrix of species distribution according t the methods off Bassey *et al.* (2023). These indices are effective in evaluating beta diversity and compositional overlap. Cluster analysis was subsequently performed using the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) in PAST (Paleontological Statistics) Software Version 3.14 (Hammer *et al.,* 2001) to visually represent floristic affinities and groupings among the studied sites Anwana *et al.* (2020).

RESULTS AND DISCUSSION

Results

Table 2 shows the Pteridophyte and Lycophytes flora in the studied wetlands, conservation status and species habit recorded. As presented, there are 17species from 15 genera representing 12 families.The table also presents a blend of lithophytic, erect, creeping, climbing and epiphytic ferns. Also, some species such as *Gleichinia linearis, Nephrolepsis bisserata, Nephrolepsis undulata* and *Phymatosorus scolopendria* exhibited more than one habit.

Table 2: Habit and Conservation Status of Ferns and Fern Allies of Studied Wetlands

Species	Habit	Conservation status
Asplenium sandersonii	Epiphytic/Lithophytic	NE
Cyclosorus interruptus	Erect	LC
Diplazium esculentum	Erect	LC
Gleichinia linearis	Erect/Climbing	NE
Lycopodium clavatum	Erect	NE
Lygodium microphyllum	Climbing	LC
Lygodium smithianum	Climbing	NE
Microgramma owariensis	Epiphytic	NE
Nephrolepis bisserata	Erect/Epiphytic	NE
Nephrolepsis undulata	Erect/Epiphytic	NE

Species	**Habit**	**Conservation status**
Oleandra distenta	Epiphytic	NE
Pityrogramma calomelanos	Erect	NE
Platycerium clavatum	Epiphytic	NE
Pteridium aquilinum	Erect	LC
Pteris tripartita	Erect	NE
Phymatosorus scolopendria	Erect and Epiphytic	DD
Selaginella kraussiana	Creeping	DD

LC: Least Concerned; NE: Not Evaluated

Table 3 shows the occurrence and relative distribution of Pteridophytes and Lycophytes in the studied wetlands. The distribution of *Cyclosorus interuptus* and *Nephrolepsis bisserata* seemed quite even as they were both present in all wetlands within the study area, whereas *Platycerium*, *Pityrogramma* and *Microgramma* were quite uneven and patchy in their distribution.

Table 3: Distribution of Ferns and Fern Allies' in Studied Wetlands

Species	**Asiok**	**Atabong**	**IkUdo**	**Etebi**	**IkUso.**	**Marina**	**Idim afia**
Asplenium sandersonii	-	-	-	+	+	-	-
Cyclosorus interruptus	++	+++	+++	+++	+	++	+++
Diplazium esculentum	-	-	-	+	+	-	-
Gleichinia linearis	+++	-	-	+++	-	-	-
Lycopodium clavatum	-	-	-	+++	-	+++	-
Lygodium microphyllum	++	++	+	+++	+	+++	-
Lygodium smithianum	++	-	-	+++	-	+++	-
Microgramma owariensis	-	-	+	-	-	-	-
Nephrolepis bisserata	++	++	+	+	+	++	+
Nephrolepsis undulata	-	-	+	-	-	+	-
Oleandra distenta	-	-	+	-	-	-	-
Pityrogramma camelomelanos	-	-		-	-	+	-
Platycerium stemaria	-	-	++	-	-	-	-
Pteridium aquilinum	-	-	+	-	-	-	-
Pteris tripartita.	-	-	-	+	-	-	-
Phymatosorus scolopendria	-	+	+++	-	+	-	-
Selaginella kraussiana	-	-	++	+++	-	+	-

Key: +++ = Abundant; ++ = Common; + = Scanty; IkUdo = Ikot Udota;; IkUso. = Ikot usoekong.

Tables 4 reveal the Jaccards's similarity coefficient for the studied wetlands. From the Sorenson matrix, Etebi and Ikot udota wetlands were the most dissimilar (0.1875 respectively) whereas Ikot Usoekong and Ataobong were the most similar in terms of ferns diversity (0.6667).

Table 4: Jaccard's Similarity Matrix for the Studied Wetlands

	Asiok	**Ataobong**	**Ikot Udota**	**Etebi**	**Ikot usoekong**	**Marina**	**Idim afia**
Asiok	1	0.42857	0.2500	0.454546	0.333333	0.40000	0.333333
Ataobong		1	0.3000	0.27273	0.666667	0.333333	0.50000
Ikot Udota			1	0.1875	0.25000	0.307692	0.222222
Etebi				1	0.454546	0.50000	0.20000
Ikot usoekong					1	0.272727	0.33333
Marina						1	0.25000
Idim afia							1

Tables 5 reveal the Sorensons's similarity coefficient for the studied wetlands. From the Sorenson matrix, Etebi and Ikot udota wetlands were the most dissimilar (0.3177) whereas Ikot Usoekong and Ataobong were the most similar in terms of taxa diversity (0.8000).

Table 5: Sorenson's Similarity Matrix for the Studied Wetlands

	Asiok	**Ataobong**	**Ikot Udota**	**Etebi**	**Ikot usoekong**	**Marina**	**Idim afia**
Asiok	1	0.6000	0.40000	0.6250	0.500	0.57143	0.50000
Ataobong		1	0.46154	0.4286	0.800	0.50000	0.66667
Ikot Udota			1	0.3158	0.400	0.47059	0.36364
Etebi				1	0.625	0.66667	0.33333
Ikot usoekong					1	0.42857	0.5000
Marina						1	0.4000
Idim afia							1

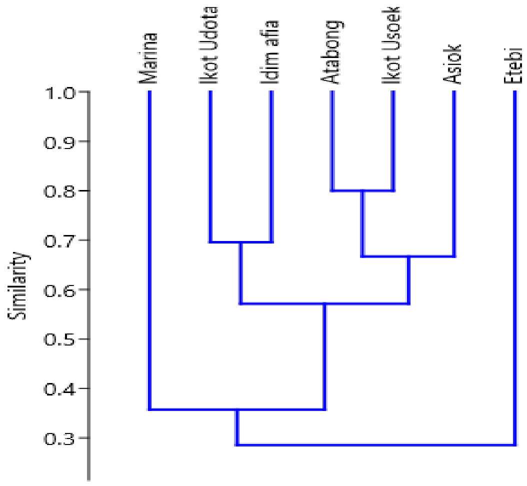

Figure 1: Dendrogram Showing Sites Relatedness Based on Floristic Similarities

Discussion

Ferns and their allies represent an evolutionarily ancient group of plants that have adapted to a wide array of ecological niches, from lowland rainforests to montane ridges, from ephemeral aquatic habitats to tree canopies. Their ecological role in wetland environments is especially critical, given their capacity for moisture retention, nutrient cycling, microhabitat creation, and soil stabilization (Winter and Amoroso, 2003; (Yusuf, 2010). The present study, which recorded 17 species from 15 genera and 12 families across seven distinct wetlands in southern Akwa Ibom State, underscores the latent floristic richness and heterogeneity embedded within these threatened ecosystems.

The observed composition spans several functional groups and growth forms including erect, epiphytic, climbing, creeping, and lithophytic ferns highlighting the structural and functional diversity within the wetland mosaic. Such diversity reflects variations in light regimes, hydrological gradients, substrate types, and biotic interactions (Kokaly *et al*., 2003). For instance, erect ferns like *Cyclosorus interruptus* are often found in seasonally inundated soils, where their morphology supports fast vertical growth and effective spore dispersal. In contrast, epiphytic species such as *Platycerium clavatum* and *Microgramma owariensis* rely on host trees and elevated humidity, suggesting more mature and less disturbed canopy structures (Adubasim *et al.,* 2018).

The ecological ubiquity of *Cyclosorus interruptus* and *Nephrolepis bisserata* across all studied sites is particularly noteworthy. These species function as ecological generalists, capable of tolerating a broad spectrum of moisture regimes, light intensities, and soil textures (Ogbemudia and Mbong, 2013). Their presence across both disturbed roadside wetlands and interior, semi-natural wetlands speaks to their phenotypic plasticity and potential role as pioneer or stabilizing species in successional dynamics. Their abundance aligns with the concept of ecological resilience — the capacity of some species to maintain functionality across a range of disturbances, thereby promoting ecosystem stability (Mbong *et al.,* 2020; Mannan *et al*., 2008).

Conversely, the absence or localized rarity of species such as *Phymatosorus scolopendria* and *Pteridium aquilinum* in certain wetlands may reflect a combination of environmental filtering and anthropogenic exclusion. As reported by Anwana *et al.* (2020), variations in floristic richness and evenness across wetlands are strongly shaped by anthropogenic pressures such as land clearing, urban encroachment, and hydrological modification. Epiphytes, in particular, are highly sensitive to changes in canopy continuity and air humidity,two conditions commonly degraded by roadside construction and deforestation (Adubasim *et al.*, 2018).

A key insight from this study emerges from the comparison of species composition using Sorenson and Jaccard similarity indices. Floristic similarity ranged from moderate to high (40–80%), with notable clustering between sites such as Ikot Usoekong and Ataobong, and clear dissimilarity between Etebi and Ikot Udota. These patterns align with beta diversity principles (the degree of species turnover between habitats) and suggest that although wetlands may share macro-environmental characteristics (e.g., rainfall, temperature), micro-environmental variables and site histories generate differential species filters (Mbong *et al*., 2020).

Cluster analysis provides additional spatial logic to these findings. The grouping of Asiok, Ataobong, Ikot Usoekong, and Idim Afia wetlands reflects a shared history of anthropogenic exposure. Located near highways or peri-urban settlements, these wetlands are likely influenced by edge effects, vehicular emissions, invasive species colonization, and altered hydrology due to poor drainage planning. As reported by Ogbemudia *et al.* (2018), spatially adjacent wetlands subjected to similar anthropogenic stress often converge in species composition not because of ecological optimality, but due to biotic homogenization (a process where native diversity is replaced by disturbance-tolerant generalists).

In contrast, the relatively higher species richness in wetlands such as Etebi, Ikot Udota, and Marina (which are spatially separated and less disturbed) underscores the importance of landscape heterogeneity and spatial insulation in maintaining biodiversity. This affirms earlier observations by Erwin (2009) and Ehrenfeld (2000) that ecosystem functionality and floristic complexity are positively correlated with ecological integrity and hydrological stability. Further ecological interpretation suggests that the distribution of fern species in the study area may be governed by principles of niche differentiation. For example, the co-occurrence of *Lygodium microphyllum* and *Lygodium smithianum* in wetlands with dense understorey vegetation and intermittent flooding points to distinct yet overlapping ecological preferences, possibly reflecting a form of habitat partitioning. Such fine-scale segregation permits coexistence among morphologically similar species and enhances local species richness (Benjamin and Manickam, 2007; Prance and Keller, 2015).

The implications of the observed patterns extend beyond pure floristic interest. Several of the identified species, including *Diplazium esculentum*, *Nephrolepis undulata*, and *Lycopodium clavatum*, possess documented ethnobotanical and medicinal uses, often harvested unsustainably by local communities (Chang *et al.,* 2010; Benjamin, 2011). Their sporadic appearance in some wetlands may not only reflect ecological selectivity but also anthropogenic extraction. As emphasized by Srivastava (2007), the dual acceptance of pteridophytes (as ecological indicators and cultural resources) necessitates urgent integration into conservation agendas. It is also imperative to acknowledge the role of wetlands as refugia for rare and specialist fern species, especially in the face of climate change and land-use intensification. With increasing habitat fragmentation and loss of connectivity, small wetland patches may serve as vital repositories of genetic diversity. The detection of *Selaginella kraussiana* in Etebi and Marina, for instance, may reflect microrefugia conditions, offering suitable microclimates for moisture-loving, creeping ferns (Mbong *et al.*, 2025).

Ultimately, the study not only affirms the ecological richness of Akwa Ibom wetlands but also signals a silent ecological attrition occurring in the face of development and neglect. The documented dissimilarity between relatively pristine and highly disturbed wetlands serves as an ecological alarm, reinforcing the need for urgent interventions. Vegetation-based monitoring, especially involving pteridophytes as bioindicators, offers a cost-effective, data-rich method of assessing ecological health and directing restoration strategies (Adam *et al.,* 2010; Kokaly *et al.,* 2003). Obviously, the floristic patterns presented herein underscore a larger narrative: that wetland integrity and species diversity are inseparable. Conservation of these fragile habitats must therefore transcend rhetorical commitments and include the preservation of their vascular cryptogamic components whose persistent silent decline may presage the erosion of ecosystem resilience itself.

CONCLUSION

The present study provides vital ecological insights into the composition, distribution, and similarity patterns of ferns and fern allies across seven threatened wetlands in southern Akwa Ibom State, Nigeria. A total of 17 species representing 15 genera and 12 families were recorded, highlighting the relatively high taxa richness in these transitional ecosystems. While some species like *Cyclosorus interruptus* and *Nephrolepis biserrata* were ubiquitous, others exhibited localized or patchy distributions likely driven by microhabitat specificity and disturbance history. Analysis of floristic similarities revealed both clustering of roadside wetlands with lower diversity and dissimilarity among less-disturbed, interior sites. These patterns underscore the impact of anthropogenic pressure and environmental heterogeneity on pteridophyte community structure. The study affirms that species distribution is influenced not only by hydrology and edaphic factors but also by anthropogenic modifications such as vegetation clearance, pollution, and habitat fragmentation. The ecological significance of these findings lies in their utility for wetland conservation planning. By establishing a baseline inventory and spatial relationship of pteridophyte assemblages, this study contributes to informed decisions in biodiversity conservation, environmental impact assessments, and ecosystem restoration efforts.

Based on the findings of this study, it is recommended that immediate conservation attention be given to the wetlands surveyed, particularly those with low species richness such as Idim Afia and Ataobong, to prevent further loss of biodiversity. Wetland management strategies should incorporate the planting of native fern species as part of ecological restoration and erosion control measures. Also, Indigenous ferns with known ethnobotanical uses should be included in public landscaping and reforestation schemes to promote both ecological and cultural sustainability. Community-based awareness programs are crucial to educate local populations on the ecological value of ferns and the need to avoid unsustainable harvesting practices. Policymakers should integrate cryptogamic flora into existing biodiversity conservation frameworks and establish protected wetland zones with regulated access. Finally, further ecological and phytosociological research should be conducted on wetland ferns to understand their ecological requirements, tolerance thresholds, and long-term population dynamics, especially under increasing anthropogenic and climatic pressures. These actions are essential for sustaining the ecological integrity of wetlands in Akwa Ibom State and beyond.

REFERENCES

Adam, E., Mutanga, O., and Rugege, D. (2010). Multispectral and hyperspectral remote sensing for identification and mapping of wetland vegetation: A review. *Wetlands Ecology and Management, 18*(3), 281–296. https://doi.org/10.1007/s11273-009-9169-2

Adubasim, C. V., Akinnibosun, H. A., Dzekewong, S. N., and Obalum, S. E. (2018). Diversity and spatial distribution of epiphytic flora associated with four tree species of partially disturbed ecosystem in tropical rainforest zone. *Journal of Tropical Agriculture, Food, Environment and Extension, 17*(3), 46–53.

Akomolafe, G. F., and Sulaimon, A. (2018). Taxonomic survey of occurrence, diversity and ethnobotany of Pteridophytes in some parts of Nasarawa State, Nigeria. *Fern Gazette, 20*(7), 269–279.

Akubundu, I. O., and Agyakwa, C. W. (1998). *A textbook of West African weeds*. International Institute of Tropical Agriculture.

Anwana, E. D., Mbong, E. O., and Etim, N. (2020). Trends in macrophytes abundance and distribution in anthropogenic perturbed lentic ecosystems in Uyo Metropolis. *Journal of Environment and Waste Management, 7*(1), 339–344.

Bassey, M. E., Anwana, E. D., Mbong, E. O., and Umoh, O. T. (2023). Diversity and distribution of vascular cryptogams in relation to elevation gradient in Osomba Range of the Cross River National Park, Cross River State. *World Journal of Applied Science and Technology, 15*(1), 26–32.

Bassey, M. E., Anwana, E. D., Umoh, O. T., and Mbong, E. O. (2024). Pteridophytes and lycophytes of Osomba Hills, Cross River State National Park. *Ceylon Journal of Science, 53*(2), 219–229.

Benjamin, A. (2011). Medicinal ferns of North Eastern India with special reference to Arunachal Pradesh. *Indian Journal of Traditional Knowledge, 10*(3), 516–522.

Benjamin, A., and Manickam, V. S. (2007). Medicinal pteridophytes from the Western Ghats. *Indian Journal of Traditional Knowledge, 6*(4), 611–618.

Chang, H. C., Gupta, S. K., and Tsay, H. S. (2010). Studies on folk medicinal fern: An example of 'Gu-Sui-Bu.' In A. Kumar, H. Fernández, and M. A. Revilla (Eds.), *Working with ferns: Issues and applications* (pp. 285–304). Springer. https://doi.org/10.1007/978-1-4419-0194-1_18

Dalziel, J. M. (1937). *The useful plants of West Tropical Africa*. Crown Agents for Overseas Governments and Administrations.

Ehrenfeld, J. G. (2000). Evaluating wetlands within an urban context. *Ecological Engineering, 15*(3–4), 253–265. https://doi.org/10.1016/S0925-8574(00)00076-4

Erwin, K. L. (2009). Wetlands and global climate change: The role of wetland restoration in a changing world. *Wetlands Ecology and Management, 17*(1), 71–84. https://doi.org/10.1007/s11273-008-9119-1

Ezekiel, A. G., Umoh, O. T., Mbong, E. O., Ntukidem, A. U., and William, R. A. (2024). Distribution and conservation status of plant species in the botanical garden and arboretum domiciled in the University of Uyo, Nigeria. *Dutse Journal of Pure and Applied Science, 10*(1b), 74–84.

Frohn, R. C., Reif, M., Lane, C., and Autrey, B. (2009). Satellite remote sensing of isolated wetlands using object-oriented classification of Landsat-7 data. *Wetlands, 29*(3), 931–941. https://doi.org/10.1672/08-131.1

Hammer, Ø., Harper, D. A. T., and Ryan, P. D. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica, 4*(1), 1–9.

Hutchinson, J., and Dalziel, J. M. (1958). *Flora of West Tropical Africa* (Vol. 1, Part 2). Crown Agents for Overseas Government and Administrations.

Kokaly, R. F., Despain, D. G., Clark, R. N., and Livo, K. E. (2003). Mapping vegetation in Yellowstone National Park using spectral feature analysis of AVIRIS data. *Remote Sensing of Environment, 84*(3), 437–456. https://doi.org/10.1016/S0034-4257(02)00133-5

Mannan, M. M., Maridass, M., and Victor, B. (2008). A review on the potential uses of ferns. *Ethnobotanical Leaflets, 2008*(33), 281–285.

Mbong, E. O., Ivon, E. A., Idio, E., Utuk, K. E., Okon, J. E., and Anwana, E. D. (2023). Correlating habitat dynamism with foliar anatomical modulations: A study with *Phymatosorus scolopendria* (Burm. F.) Ching. *World Journal of Applied Science and Technology, 15*(1), 61–68.

Mbong, E. O., Osu, S. R., Uboh, D. G., and Ekpo, I. (2020). Abundance and distribution of species in relation to soil properties in sedge-dominated habitats in Uyo Metropolis, Southern Nigeria. *Global Journal of Ecology, 5*(1), 24–29.

Mbong, E. O., Chukwudi, P., Okpoko, V. O., Abah, J. P. and Umoru, J. (2025). Growth forms and plant conservation status in impacted lotic wetlands associated with the Lower Niger River Basin, Delta State, Nigeria. *Asian Journal of Research in Biology, 8*(1), 133–145.

Mitsch, W. J., and Gosselink, J. G. (2000). The value of wetlands: Importance of scale and landscape setting. *Ecological Economics, 35*(1), 25–33. https://doi.org/10.1016/S0921-8009(00)00165-8

Ogbemudia, F. O., and Mbong, E. O. (2013). Studies on some pedological indices, nutrient flux pattern and plant distribution in metropolitan dumpsites in Uyo, Akwa Ibom State. *Indian Journal of Pharmaceutical and Biological Research, 1*(2), 40–45.

Ogbemudia, F. O., Anwana, E. D., Mbong, E. O., and Joshua, E. E. (2014). Plant diversity status and soil physicochemistry in a flood plain. *International Journal of Research, 1*(10), 1977–1985.

Ogbemudia, F. O., Ita, R. E., Mbong, E. O., and Okoroafor, O. V. (2018). Spatial characterization of flora diversity and soil relations using GIS-based models in a riverine wetland of Imo River Basin. *New York Science Journal, 11*(5), 59–66.

Ogbemudia, F. O., Anwana, E. D., Onyebule, C. L., and Mbong, E. O. (2025). Epiphytic vascular cryptogams as bioindicators of atmospheric heavy metals pollution in Eket wetlands, Nigeria. *Asian Journal of Research in Botany, 8*(1), 214–226.

Oloyede, F. A., Akomolafe, G. F., and Odiwe, I. A. (2013). Arsenic hyperaccumulation and phytoremediation potentials of *Pteris vittata* and *P. ensiformis* (ferns) in Nigeria. *Acta Botanica Hungarica, 55*(3–4), 377–384. https://doi.org/10.1556/ABot.55.2003.3-4.8

Owor, M., Muwanga, A., and Pohl, W. (2007). Wetland change detection and inundation north of Lake George, western Uganda using Landsat data. *African Journal of Science and Technology, 8*(1), 94–106.

PPG I. (2016). A community-derived classification for extant lycophytes and ferns. *Journal of Systematics and Evolution, 54*(6), 563–603. https://doi.org/10.1111/jse.12229

Prance, G., and Keller, H. A. (2015). The ethnobotany of ferns and fern allies. *British Pteridological Society, 20*(1), 1–14.

Srivastava, K. (2007). Importance of ferns in human medicine. *Ethnobotanical Leaflets, 11*(1), 231–234.

Ubom, R. M. (2006). *Biometry*. Abams Publishers.

Winter, W., and Amoroso, V. B. (2003). *Plant resources of South-East Asia No. 15(2): Cryptogams: Ferns and fern allies*. Backhuys Publishers.

Yusuf, U. K. (2010). *Ferns of the Malaysian rainforest: A journey through the fern world*. Universiti Putra Malaysia Press.