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Original Research Article

Fern Species Diversity in Otuoke University Community, Nigeria: Patterns and Conservation Implications

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Abstract: This study assessed fern species diversity within Otuoke University Community, Nigeria, to examine distribution patterns and conservation implications. Field surveys were conducted in two assessment areas (AA1: mixed-use institutional landscape; AA2: closed-canopy forest). A progressive time-meander sampling approach was employed, and sampling effort was standardized to 120 minutes, with 60 minutes allocated per assessment area. All vascular fern sporophytes occurring within approximately 2metres on either side of the meander path were recorded. Species abundance was estimated using a modified Braun-Blanquet scale based on patch size. Moisture preference was assessed using hydrological site index, while disturbance-tolerance was evaluated using habitat fidelity index. A total of 28 fern species were recorded, with uneven distribution between the mixed-use campus (AA1) and the less-disturbed forest habitat (AA2). Forest-restricted species, predominantly shade-dependent and moisture-loving, indicated ecological significance of their undisturbed habitats. In contrast, only seven disturbance-tolerant generalists (*M. mauritiana, M. punctatum, N. biserrata, N. cordifolia, N. undulata, P. calomelanos* and *P. aquilinum*) were confined to AA1. Growth forms which included terrestrial, epiphytic, climbing, aquatic, and semi-aquatic species reflect structural heterogeneity across forest stands, wetlands, floodplains, and regrowth areas. Species distributions were associated with moisture availability, with many taxa restricted to creek edges, marshes, and forest swamps. High tolerant species (*P. aquilinum*, *D. linearis*, *N. biserrata* and *N. cordifolia*) dominated fallows, edges and regrowth, whereas low-tolerance forest specialists (*D. ballardianum*, *O.distenta*, *B. acrostichoides* and *P. stemaris)* persisted only in shaded understories. Epiphytic species exhibited moderate to low disturbance tolerance. And patch-dynamics analysis revealed variations in ecological dominance, widespread species exhibited stable populations, while species with low frequency and small patches showed reduced resilience. Habitat heterogeneity, moisture availability, and disturbance intensity structured the fern species diversity, whereas continued habitat modification threatens this diversity; therefore, conservation measures should prioritize forest understories, wetlands, creek systems, and mature trees through biodiversity-sensitive campus planning.

Keywords: Fern Diversity, Ecological Patterns, Conservation, Otuoke Varsity Community, Nigeria.

INTRODUCTION

Ferns represent an ecologically and evolutionarily important group of cryptogams (non-seed vascular plants) that occupy a significant position in tropical ecosystems (Page, 2002; Rahmad and Akomolafe, 2018). They rely heavily on water for reproduction, particularly during fertilization, which largely confines them to wetland and shaded environments (Watkins and Cardelus, 2012). As one of the oldest lineages of vascular plants, ferns thrive in shaded and humid habitats where they contribute to forest understory biodiversity, soil moisture retention, nutrient cycling, and microhabitat formation. Their

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sensitivity to variations in microclimatic conditions such as humidity, shade intensity, and disturbance regimes renders them reliable bioindicators of environmental and ecological change (Qian *et al*., 2022; Olubode and Ighodalo, 2018; Linda *et al*., 2022).

In southern Nigeria, ferns represent the dominant component of the pteridophytic flora and are frequently encountered along stream banks, marsh, and beneath dense forest canopies characterized by high relative humidity and low light penetration (Akinsoji *et al*., 2016; Linda *et al*., 2022). Fern assemblages exhibit marked responsiveness to microclimatic gradients and habitat heterogeneity, particularly those related to soil moisture dynamics and hydrological regimes, which determine species distribution, abundance, and niche specialization (Cicuzza and Mammides, 2022). Their extensive rhizome and root networks contribute significantly to soil stabilization and erosion control, particularly in riparian and slope ecosystems. And like grass, ferns try to establish their dominance in open spaces; moreover, many fern taxa display narrow ecological amplitudes and high habitat specificity (Chau and Chu, 2017; Bonari *et al*., 2022; Schmidt, *et al*., 2024). Several fern species colonize tree trunks and branches without deriving nutrients parasitically, enhancing the vertical stratification of forest habitats (Flores-Arguelles *et al*., 2022). These ferns contribute to canopy-level biodiversity, promote the retention of atmospheric moisture, and create microhabitats that sustain diverse assemblages of insects, bryophytes, and microorganisms (Nieder *et al*., 2001; Chen *et al*., 2023). Within Bayelsa State's landscape, ferns occupy ecological niches often underutilized by seed-bearing plants, thereby contributing substantially to overall floristic diversity. However, despite their ecological and functional relevance, ferns remain underrepresented in biodiversity inventories and are frequently excluded from general vegetation assessments (Egbe *et al*., 2025). Their distribution and abundance though influenced by multiple environmental and anthropogenic factors; empirical studies revealed a marked reduction in their richness across disturbed habitats (Bassey, 2021; Bonari *et al.*, 2022). Pteridophyte species sensitivity to environmental degradation are often used as gauge for forest ecosystem health (Akinsoji *et al.,* 2016; Azila *et al*.,2021; Bulafu *et al*., 2022; Linda *et al.* 2022).

Otuoke varsity is a lowland rainforest community, its ecological landscape remains largely unexplored within the scientific literature. The area is typified by swamp vegetation and intricate hydrological systems that create favorable microhabitats for fern proliferation. Despite these favourable ecological conditions, there is a dearth of studies on fern species within the community and the broader Bayelsa State. The absence of baseline information constitutes a gap in understanding local fern species diversity (Wani and Pant, 2023). Thus, a systematic investigation of fern species diversity is imperative to understanding fern distribution patterns, habitat associations, and ecological significance. Such an assessment will not only contribute to the documentation of regional biodiversity but also inform conservation and management strategies aimed at protecting sensitive wetland and forest ecosystems in Bayelsa State.

MATERIALS AND METHODS

The study was undertaken at two assessment areas (AA1 and AA2) within Federal University Otuoke (FUO). The selection of the sampling sites was done by considering the soil characteristics and the hydrological setting observed in the study area. Federal University Otuoke is located at Ogbia Local Government Area of Bayelsa State, Nigeria. It lies approximately at 4°47'35"N 6°19'28"E within lowland forest zone. The area is tropical and experiences annual rainfall ranging from 2,500 to 4,500 mm and mean monthly temperatures between 20°C and 35°C, with consistently high relative humidity throughout most of the year. Its terrain is predominantly lowland rainforest, interspersed with creeks, marshes, and river systems, the common relief of the region, creating diverse microhabitats rich in fern species diversity.

Fern Sampling Procedure and Data Collection

A progressive timed meander sampling approach was employed in this study, with a focus on fern species observation rather than exhaustive spatial coverage. The method is suitable for rapid biodiversity assessments in heterogeneous habitats where ferns distributions are typically patchy. Sampling was conducted within two Assessment Areas (AAs) totaling 6,129 m² at the Federal University Otuoke. Assessment Area 1 (AA1) comprised the mixed-use institutional landscape within the East Campus, including the botanical garden, whereas Assessment Area 2 (AA2) was situated in an adjacent closed-canopy forest zone. Each AA was subdivided into five collection sites, yielding ten collection sites across the study area.

Sampling effort was standardized to 120 minutes, with 60 minutes allocated to each AA using a visible timer. All vascular fern sporophytes occurring within approximately 2m on either side of the meander path were recorded across multiple microhabitats, including understory vegetation, fallen logs, stream margins, marshes, regrowth areas, and forested swamps. Species occurrences were recorded by collection site, and species frequency was calculated as the number of sites in which each species was present. Species abundance was estimated using a modified Braun-Blanquet scale adapted for patch-size estimation (Westhoff and van der Maarel, 1978). Abundance categories were defined as: 1= single individual (single tuft); 2 = small patch (2-10 ramets); 3 = moderate patch (11-50 individuals); 4 = large patch (51-100 individuals); and 5 = dominant patch (>100 individuals). For each species, the mean abundance category was calculated across occupied sites, and an abundance score was derived as the product of species frequency and mean abundance category. Higher scores therefore indicate greater species prominence within the study area.

Ferns were identified *in situ* whenever possible. Where immediate identification was uncertain, voucher specimens showing diagnostic frond and sori characteristics were collected for later identification. Multiple counts of individuals from the same clump were excluded to prevent overestimation. Species exhibiting clear microhabitat specificity or local dominance were noted. Additionally, the time of first and last detection was recorded, along with the cumulative time spent at dense patches when prolonged observation occurred. Moisture preference was assessed using a hydrological site index reflecting the characteristic soil-water conditions in which each species predominantly occurred. Species restricted to saturated substrates were classified as very moist, those typical of periodically inundated habitats as floodplain species, species occurring in consistently moist but non-waterlogged soils as moist, species associated with moderately moist substrates as moderate, and those frequent in well-drained or seasonally dry habitats as dry-site species, following established categorical frameworks (Ellenberg 1988; Ellenberg *et al.*, 1992; Kirby and Thomas, 2002).

Shade-tolerance categories were defined according to established ecological frameworks (Givnish, 1988; Kirby and Thomas, 2002; Mehltreter *et al.,* 2010; Mirkka *et al*., 2007). Species confined to deep forest understories were classified as deep-shade tolerant, those occurring under closed but partially filtered canopies as shade tolerant, species common in semi-open or edge habitats as moderate shade tolerant, and species frequent in open, high-light environments as sun tolerant (Valladares and Niinemets, 2008; Givnish, 1988). Disturbance tolerance was assessed using habitat fidelity index. Species were classified from low to very high tolerance based on their predominant occurrence in relic forests, secondary forests and edges, agricultural landscapes, and heavily disturbed substrates (Mueller-Dombois and Ellenberg, 1974; Dufrene and Legendre, 1997; Mehltreter *et al*., 2010).

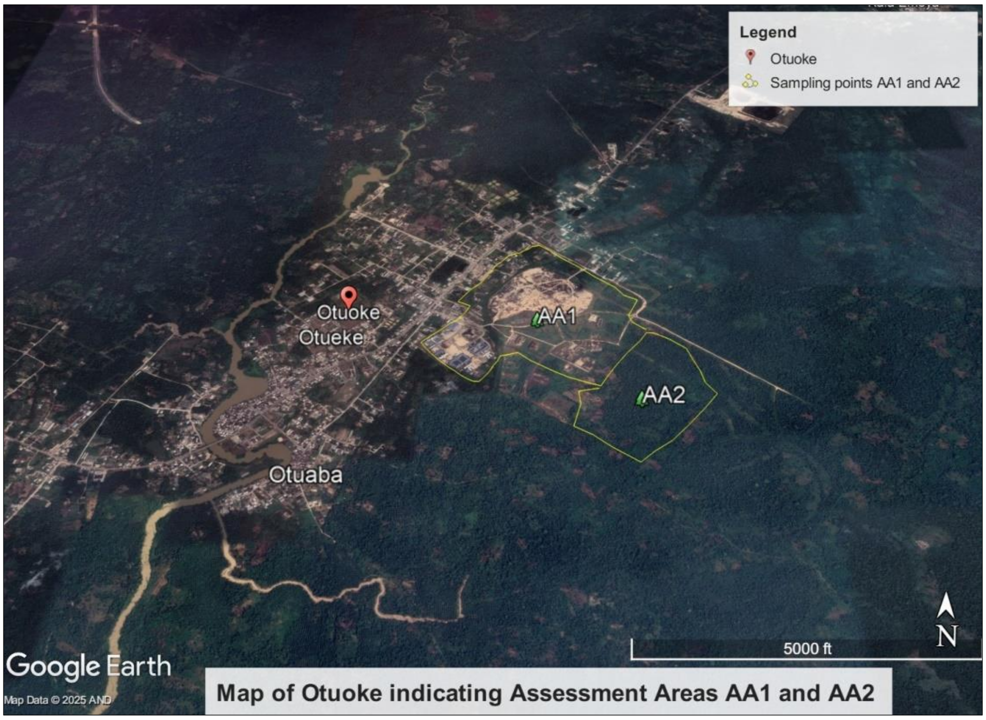

Fig. 1: Map of Otuoke, Bayelsa State, Nigeria, showing Federal University, Otuoke, the assessment area

Data Analysis

The distribution of the investigated ferns species per family across the assessment areas was presented using tables of numbers and percentages frequency. Frequency (%) and median category were used to determine each species' abundance status.

RESULTS AND DISCUSSION

The occurrence patterns of fern species across the two assessment areas (Table 1) shows clear habitat-related differences in fern diversity within Otuoke University Community. A total of twenty-eight (28) fern species were recorded, with an uneven distribution between the mixed-use institutional campus (AA1) and the less-disturbed forest habitat (AA2). The higher number of species restricted to AA2 affirms the importance of relatively undisturbed forest environments in sustaining fern diversity. Most of the forest-restricted species were shade-dependent, moisture-loving, and disturbance-sensitive, indicating that AA2 provides relatively stable microclimatic conditions essential for fern establishment and persistence. Similar patterns have been reported in tropical forest ecosystems, where fern richness is associated with intact canopy cover and reduced anthropogenic disturbance (Oseguera-Olalde *et al*. 2002; Lee *et al*., 2025). In contrast, only seven species (*M. mauritiana*, *M. punctatum*, *N. biserrata*, *N. cordifolia*, *N. undulata*, *P. calomelanos* and *P. aquilinum)* were restricted to AA1. These species were ecological generalists with high tolerance to disturbance and environmental variability. Their occurrence in AA1 shows the influence of land-use activities within the university campus. This observation is in consistent with Walker and Sharpe (2010) and Zhu *et al*., (2016), who reported that disturbed habitats tend to favour fast-growing, light-tolerant, and clonal fern species capable of rapid colonization.

Table 1: Occurrence Patterns of Fern Species in the Assessment Areas

Species	Family	Occurrence in *AA1* (Mixed-use campus)	Occurrence in *AA2* (Less-disturbed forest)	Habitat category
Acrostichum aureum (L.)	Pteridaceae	No	Yes	AA2 only
Arthropteris orientalis	Tectariaceae	No	Yes	AA2 only
Asplenium sandersonii (Hook)	Aspleniaceae	No	Yes	AA2 only
Bolbitis acrostichoides (Afzal. ex. Sw) Ching	Dryopteridaceae	No	Yes	AA2 only
Ceratopteris cornuta (P. Beauv.) Lepr.	Pteridaceae	No	Yes	AA2 only
Cyclosorus interruptus	Thelypteridaceae	Yes	Yes	Both
Dicranopteris linearis (Burm. F.) Underw.	Gleicheniaceae	Yes	Yes	Both
Didymoglossum ballardianum (Alston) J.P. Roux	Hymenophyllaceae	No	Yes	AA2 only
Lomariopsis guineensis (underw.) Alston	Lomariopsidaceae	No	Yes	AA2 only
Lomariopsis hederacea (Alston)	Lomariopsidaceae	No	Yes	AA2 only
Lygodium microphyllum (Cav.) R.Br.	Lygodiaceae	Yes	Yes	Both
Microgramma mauritiana	Polypodiaceae	Yes	No	AA1 only
Microgramma owariensis (Desv.) Alston	Polypodiaceae	No	Yes	AA2 only
Microsorum punctatum (L.) Copel.	Polypodiaceae	Yes	No	AA1 only
Nephrolepis biserrata (Schott)	Nephrolepidaceae	Yes	No	AA1 only
Nephrolepis cordifolia (L) C. Presl.	Nephrolepidaceae	Yes	No	AA1 only
Nephrolepis undulata (Afzel. ex Sw.)	Nephrolepidaceae	Yes	No	AA1 only
Oleandra distenta	Oleandraceae	Yes	Yes	Both
Phymatosorus scolopendria	Polypodiaceae	Yes	Yes	Both
Pityrogramma calomelanos (L.) link	Pteridaceae	Yes	No	AA1 only
Platycerium bifurcatun	Polypodiaceae	Yes	Yes	Both
Platycerium elephantotis (Schweinf.)	Polypodiaceae	Yes	Yes	Both
Platycerium stemaris	Polypodiaceae	Yes	Yes	Both
Platycerium superbum	Polypodiaceae	Yes	Yes	Both
Pneumalopteris afra (Christ)	Thelypteridaceae	No	Yes	AA2 only
Pteridium aquilinum (L.) Kuhn	Dennstaedtiaceae	Yes	No	AA1 only
Pteris togoensis	Pteridaceae	Yes	Yes	Both
Pteris tripartita (Sw.)	Pteridaceae	Yes	Yes	Both
Note: AA1 = Mixed-use institutional campus; AA2 = Less-disturbed forest habitat.				

Twelve species occurred in both AA1 and AA2, suggesting broad ecological amplitude and adaptive flexibility. Species with such wide distributions are typically capable of exploiting diverse microhabitats and persisting under varying disturbance regimes. Their presence across both habitats enhances functional connectivity within the fern community and contributes to ecosystem resilience, as observed in other tropical human-modified landscapes (Chazdon, 2008; Loreau *et al.,* 2003).

The niche profiles of the fern species recorded in the study area (Table 2) indicate the role of habitat heterogeneity in shaping fern diversity within the Varsity Community. The wide range of growth forms (terrestrial, epiphytic, climbers, aquatic and semi-aquatic) reflects the structural complexity of the landscape which includes forest stands, wetlands, floodplains, regrowth areas and disturbed edges. Habitat heterogeneity has been widely recognized as a key determinant of fern species richness in tropical ecosystems, as it creates multiple ecological niches that facilitate species coexistence (Tuomisto *et al*., 2014; Jones *et al*., 2016; Nagalingum *et al*., 2015). Moisture availability emerged as a major ecological driver influencing fern distribution. Most of the species exhibited preferences for moist to very moist or floodplain conditions, with several taxa restricted to creek edges, marshes and forest swamps. Aquatic and semi-aquatic species such as A. aureum, *C. interruptus C. cornuta, B. acrostichoides, L. guineensis, P. afra* were strongly associated with permanently or seasonally inundated habitats. These findings are consistent with previous reports indicating that fern diversity in lowland tropical regions is closely linked to hydrological stability and soil moisture availability (Viana and Dalling 2022; Lee *et al*., 2025; Machado *et al*., 2025). Consequently, hydrological alterations such as sand filling and water pollution may disproportionately threaten moisture-dependent fern taxa.

Table 2: Niche Profiles of Ferns Encountered in the Assessment Areas

Species	Growth form	Moisture Preference	Shade Tolerance	Disturbance Tolerance	Typical microhabitat
A. sandersonii	epiphytic	moderate	sun tolerant	low - moderate	tree trunks
A. aureum	terrestrial (swamp)	Floodplain	sun tolerant	high	forest swamp, brackish areas
A. orientalis	epiphytic	moist	moderate shade	low - moderate	tree trunks
B. acrostichoides	terrestrial/aquatic	very moist	deep shade	low	creek edge, marsh
C. cornuta	aquatic	floodplain	sun tolerant	high	creek margins, marshes
C. interruptus	terrestrial	very moist	sun - moderate shade	moderate	creek edges, marshes
D. linearis	creeping	moist	sun tolerant	very high	regrowth area, forest edges
D. ballardianum	epiphytic/ terrestrial	moist	deep shade	low	Shaded, understory,
L. guineensis	epiphyte & aquatic	very moist - floodplain	moderate shade	moderate	creek edges & marshes
L. hederacea	epiphytic	very moist	moderate shade	moderate	tree trunks
L. microphyllum	climber	moist	sun - shade	high	regrowth areas & edges
M. owariensis	epiphytic	moist	moderate shade	moderate	tree trunks
M. punctatum	epiphytic	moist	moderate shade	moderate	tree trunks
Microgramma mauritiana	epiphytic	moist	moderate shade	low - moderate	tree trunks
N. biserrata	terrestrial	moist-floodplain	sun - moderate shade	very high	marshes, tree trunks, logs
N. cordifolia	terrestrial	moist - floodplain	sun – moderate shade	very high	marshes, tree trunks, logs
N. undulata	terrestrial	moist - floodplain	sun - moderate shade	low to moderate	marshes, swamps
O. distenta	epiphytic	moist	shade - moderate	low	undisturbed forest, tree trunks, understory
P. scolopendria	epiphytic	moist	sun - moderate shade	Moderate - high	forest edges
P. afra	semi aquatic	floodplain	moderate shade	moderate	marshes, swamps
P. aquilinum	terrestrial	moist	sun tolerant	very high	fallows, edges
P. bifurcatum	epiphytic	moist	moderate shade	moderate	tree trunks
P. calomelanos	terrestrial	moist - dry	sun - shade	high	regrowth area, forest edges
P. elephantois	epiphytic	moist	moderate shade	moderate	tree trunks
P. stemaris	epiphytic	moist	shade tolerant	low	tree trunks
P. superbum	epiphytic	moist	Shade tolerant	moderate	tree trunks
P. togoensis	terrestrial	moist	moderate shade	moderate	fallows, edges
P. tripartita	terrestrial	moist	shade - moderate	moderate	regrowth area, forest edges

A clear disturbance gradient was evident in the fern assemblage, species with very high disturbance-tolerance (*P. aquilinum*, *D. linearis*, *N. biserrata* and *N. cordifolia*) were dominant in fallows, forest edges and regrowth areas. These species are widely recognized as aggressive colonizers of disturbed landscapes, often forming extensive monospecific stands that suppress other vegetation (Kato-Noguchi, 2015), compared to species with low disturbance tolerance (forest specialists), *D. ballardianum*, *O.distenta*, *B. acrostichoides* and *P. stemaris* which were restricted to shaded understories and undisturbed forest patches. This pattern aligns with Watkins *et al*., (2007) and Kluge and Kessler (2011), who opined that anthropogenic disturbance selectively filters fern communities, favoring generalists while marginalizing habitat specialists. The relatively high representation of epiphytic ferns reflects the availability of mature trees and vertical habitat stratification within part of the study area. However, most epiphytes exhibited low to moderate disturbance tolerance, suggesting vulnerability to tree removal and infrastructural expansion. Epiphytic ferns have been widely proposed as sensitive indicators of forest integrity due to their dependence on stable microclimates and host tree continuity (Hietz, 2010; Zotz and Bader, 2009). Species confined to wetlands and creek margins corroborate the ecological importance of these habitats as refugia for specialized fern species. Wetlands typically support species with narrow ecological requirements and low tolerance, a pattern also observed in other tropical lowland ecosystems (Mbong *et al.,* 2025; Oseguera-Olalde, 2002).

Patch dynamics and abundance estimates (Table 3) revealed marked variation in distribution, dominance and ecological prominence among the fern taxa. Species with high frequency and large average patch sizes recorded the highest abundance scores, indicating strong ecological dominance. Extensive and continuous patches observed for N. *biserrata*, C. *interruptus*, and D. *linearis* suggest vigorous vegetative spread and ecological adaptability. Such traits are characteristic of disturbance-tolerant ferns, which often play important roles in ground-cover formation and microhabitat regulation (Page, 2002; Silva *et al*., 2018). Moderate to high abundance scores recorded for *M. mauritiana*, *M. punctatum*, *N. cordifolia* and *P. stemaris* indicate stable populations capable of persisting under current environmental conditions. Their consistent patch formation suggests favorable interactions among light availability, moisture and substrate conditions. Compared to low frequency and small patch sizes species *L. guineensis, L. hederacea, P. calomelanos* and *P. togoensis* which exhibited low abundance scores, indicating restricted distributions and potentially reduced population resilience. Such patterns are typical of specialist ferns, often more vulnerable to habitat fragmentation and microclimatic changes in disturbed tropical landscapes (Kessler *et al*., 2011; Sundue *et al*., 2015). The coexistence of large, continuous patches alongside fragmented, single-tuft populations reflects a mosaic of disturbed and semi-natural habitats within the study area. Although this mosaic currently supports relatively high species richness, yet sustained anthropogenic pressure may lead to long-term community homogenization dominated by aggressive generalist species.

Table 3: Patch Dynamics and Abundance Estimates of Fern Taxa

Species	Frequency (out of 10 segments)	Frequency (%)	Average patch size category	Abundance score	Typical patch size
A. aureum	1	10	2	20	small patches
A. orientalis	2	20	2	40	"
A. sandersonii	2	20	3	60	moderate
B. acrostichoides	4	40	2	80	small patches
C. cornuta	3	30	2	60	"
C. interruptus	4	40	4	160	large patches
D. linearis	5	50	3	150	moderate
D. ballardianum	2	20	2	40	small patches
L. guineensis	2	20	1	20	single tuft
L. hederacea	1	10	1	10	"
L. microphyllum	3	30	3	90	moderate
M. mauritiana	4	40	3	120	"
M. owariensis	3	30	2	60	small patches
M. punctatum	4	40	3	120	moderate
N. biserrata	5	50	4	200	large patches
N. cordifolia	4	40	3	120	moderate
N. undulata	2	20	3	60	"
O. distenta	3	30	2	60	small patches
P. scolopendria	4	40	2	80	"
P. calomelanos	1	10	1	10	single tuft
P. bifurcatun	2	20	1	20	"

Species	Frequency (out of 10 segments)	Frequency (%)	Average patch size category	Abundance score	Typical patch size
P. elephantotis	4	40	2	80	small patches
P. stemaris	4	40	3	120	moderate
P. superbum	1	10	2	20	small patches
P. afra	2	20	3	60	moderate
P. aquilinum	1	10	2	20	small patches
P. togoensis	1	10	1	10	single tuft
P. tripartita	3	30	2	60	small patches
Note: Abundance score = frequency (%) × median patch size category; Higher scores indicate greater overall abundance and ecological prominence					

CONCLUSION

Fern diversity in the Otuoke University community shows habitat heterogeneity, moisture, and disturbance levels. The forests and wetlands support sensitive specialists, while the campus favors disturbance-tolerant species. Moreover, ongoing habitat alteration threatens diversity; thus, conservation should protect forest understories, wetlands, creek systems, and mature trees through biodiversity-sensitive campus planning.

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