CORRELATING HABITAT DYNAMISM WITH FOLIAR ANATOMICAL MODULATIONS: A STUDY WITH *Phymatosorus scolopendria* (Burm. F.) CHING.

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***MBONG[1], E. O., IVON[4], E. A., IDIO[2], E., UTUK[2], K.E., OKON[3], J. E AND ANWANA[2], E. D.**
[1.]Department of Biological Science, Ritman University, Ikot Ekpene,
[2.]Department of Botany and Ecological Studies, University of Uyo, Uyo.
[3.] Department of Botany, Akwa Ibom State University, Ikot Akpaden, Mkpat Enin.
[4] Department of Science Laboratory Technology, University of Calabar, Calabar.
mbongemem@yahoo.com, 09035374893

ABSTRACT
There is a dearth in ecological details on *Cryptogamia* when compared to available literature on higher plants. Hence, we investigated the extent of variation in altitude, light intensity and sunlight duration existing in four contrasting habitats dominated by *Phymatosorus scolopendria* in relation to fern foliar anatomical dynamics using standard anatomical procedures and ecological protocol. The species consistently possessed diacytic and anisocytic stomata across the habitats whereas anomocytic stomata were also found in the shrub epiphytes. Similarly, unicellular trichomes were consistently present in epiphytic plant forms while oil droplets were consistent throughout except in the tree epiphytes. Also, the stomatal index and number of stomata differed significantly ($P<0.05$) and were highest in the epiphytes growing on the tree barks (17.337±3.00; 14.33±1.154) but least in the erect forms (12.875±1.10; 8.67±0.577) respectively. The lithophytes recorded highest number of epidermal cells (76.67±15.280) whereas the erect forms recorded the least (46.33±4.041). Altitude varied between 8.23 to 10.36 m; light intensity ranged between 1045 to 13088 lux while sunlight duration ranged from 2 to 8 hours/day. Correlation analysis revealed significant ($P<0.05$ and $P<0.01$) coefficients. Specifically, altitude indicated strong positive association with light intensity ($r= 0.987^*$) and sunlight duration (r= 0.990**) while light intensity correlated strongly with sunlight duration (r= 0.958). The stomatal types were strongly associated with altitude (r=0.679), light intensity (r= 0.769) and sunlight duration (0.570) while stomatal index correlated inversely with altitude (r= - 0.505) and sunlight duration (r= - 0.553). Implicitly, shady habitats with short durations of low light intensity induced higher stomatal development and density while prolonged sunlight duration and increasing light intensity retained low stomatal density in this plant. This pattern indicates a close association between species anatomical progression in relation to prevailing environmental conditions. This information reveals aspects of plant survival mechanism in different environmental scenarios and may aid future conservation efforts.

KEYWORDS: Anatomical, Stomata, Habitat, Correlation, light intensity, Altitude.

INTRODUCTION

Vascular seedless plants are a vast group of plants diversity which reproduce not through seeds but by means of scores of spores. *Phymatosorus scolopendria* (Burm. F.) Ching also termed as musk- fern or wart-fern is widely spread in different parts of the Nigeria. It is an ethno-medicinally relevant fern and so is used by people belonging to different tribes and continents for some age long perceived therapeutic properties. Amongst the Indo-Chinese, the fronds of this fern are prepared by pounding and are used for treatment of filiariasis, inflammations and boils. The full fronds are placed on mats and beddings to serve as insect repellent while the young fronds have been reported for the treatment of chronic diarrhoea (Mannan *et. al.* 2008). Among the Fiji locals, leaf juice is used for treatment of breasts swellings, stomach upset and boils (MPSP, 1998). Its stipes are often scattered and may vary between 50 to 400 millimetres in length. Its frond reflects conspicuous variability in size and may be simple to lanceolate, pinnatified or pinnatisect in form, may reach 100 to 400 millimetres in length. Its Costae are prominent with a venation that is barely visible. Its sori are shallowly immersed, large, and conspicuously occur on the adaxial surface; occurring along the main veins in single rows, or may be scattered, but not numerous (Sujatha, Ramya, Gayathri and Catharin 2018).

Plants growth, development and productivity is adversely affected by the nature and intensity of the various forms of biotic and abiotic stress factors it is exposed to. Hence, environmental gradient may induce or contribute to a wide range of plant responses ranging from alterations in cellular metabolism, anatomical adjustments, gene expression as well as distinctive phenotypic adjustments. This may further lead to variations in growth rate, plant productivity, proximate values, phytochemical constitution among individuals of the same population (Dujardin *et al.*, 2011). There are well known plant responses and adaptations reported for numerous species as means of evading potentially harmful influences emanating from the array of abiotic and biotic stressors present within its habitat (Hegazy *et al.*, 2010). Some of these stressors include light intensity, drought, salinity, flooding, water logging, high temperatures, nutrient imbalances etc.

Kahmen and Poschlod, (2008), Dujardin *et al.*, (2011), Roux *et al.*, (2017) and other erudite scholars have traced the variations in biochemical, anatomical, morphological, histological and reproductive traits of different species of higher plants in line with the direction of environmental gradient with little or no details on *Cryptogamic* flora. Typically, *Phymatosorus scolopendria* a common cryptogam with wide habitat affiliations within our locality has received very little attention. Currently, previous studies on the plant clearly focused on its phytochemical profile, ethno-botanical significance and biological activities (Mannan, 2008; Sujhatha *et. al.* 2018; Balada *et. al.* 2022). This leaves a lacuna on the adaptive response of the plant to different habitat circumstances as revealed by its anatomical, reproductive and biochemical features. Therefore, this study was carried out to investigate the direction to which the combinations of a range of specific environmental factors in contrasting habitat formations interlace with anatomical features of *Phymatosorus scolopendria* populations within a peri-urban surburb in Eket Local Government Area. Its findings will add to the existing corpus of literature on the ecology of the indigenous ferns and consequently fill existing knowledge gap within the area.

MATERIALS AND METHODS

Study Area

The study was conducted within the vicinity of Heritage Polytechnic, Ikot Udota village- a Peri urban community along the southern axis of Eket Local Government area. Eket is one of the major towns within the southern axis of Akwa Ibom State. It is situated at 4.64ºN latitude, 7.92ºE longitude and 153 meters elevation above the sea level. Eket is one of the oil producing local Government Areas in Nigeria, having about 25,569 inhabitants. The average annual temperature in Eket is 26.7ºC. The annual rainfall average reaches 3119 mm, with the rain normally intensifying from June to October which may extends to April sometimes. The area records both dry and wet seasons and January is mostly the driest month of the year. The area falls with the tropical climate zone and the dominant plant cover is made up of trees, shrubs, farmlands and patches of fragmented oil palm plantation. Occupations carried out in Eket include farming, fishing, trading, hunting, wood-carving, craft creations and pottery (AKSG, 2008; Mbong, *et. al.* 2020a).

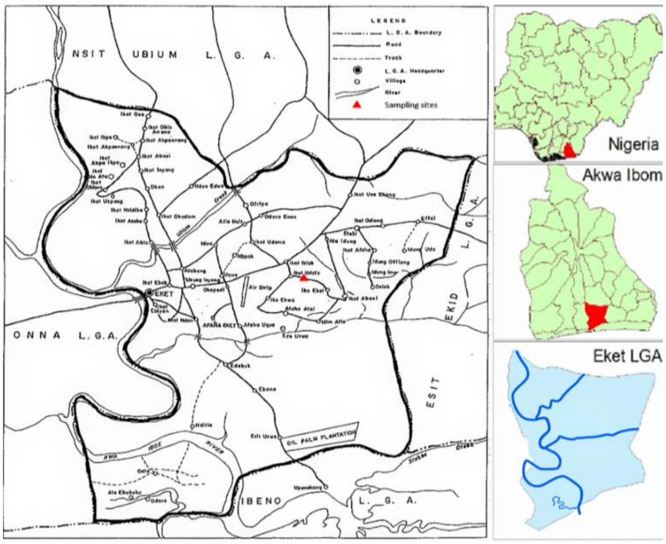


Figure 1: Map of Study area showing sampling Location

Plant Collection

Seven individuals of *Phymatosorus scolopendria* were randomly collected from four different habitat formations within Ikot Udota village, Eket and duly authenticated by a taxonomist in the University of Uyo Herbarium. The fresh parts of plants were used for the identification and classification and to study the gross internal features of the fern fronds. Plant samples collected were preserved in FAA (Formalin Acetic Acid Alcohol) for anatomical studies (Johansen, 1940).

Anatomical procedure: The preserved plant material grouped based on habitat formations and were rinsed with distilled water. Small portions were obtained from the standard medium part of well expanded fronds. The epidermal peels of both abaxial and adaxial surfaces were made by placing the frond blade on a clean glass slide, with the surface to be studied facing down.

The specimens were irrigated with water, holding it downward from one end and then the epidermis above the desired surface was scrapped-off carefully with sharp razor blade. The loose cells were washed away from the epidermis peels with the aid of a soft camel hair brush. The cleared portion of the leaf finally washed in 3 - 4 changes of distilled water (Killedar *et al.,* 2014)

The epidermal peels were stained in 1% aqueous solution of safranin -O for 4-8 minutes, carefully washed in water to remove excess stain and mounted in 10% glycerol on a clean glass slide, covered with a glass cover slid, airtight with nail vanish and viewed using Olympus CX21 binocular microscope. Photomicrographs were taken using an Olympus CX21 binocular microscope fitted with an MD500 amscope microscope eyepiece camera.

Determination of Environmental parameters.

Altitude was determined using handheld GPS device (Garmin-Etrex-10) according to the methods of Mbong et. al. (2020b), Light Intensity was determined in-situ with the aid of MT-912 digital light meter according to the methods of Connor (1958) Five successive readings were taken simultaneously in the four habitats within intervals of 10 seconds for each reading. The mean of the five series determinations taken was computed and recorded as the light intensity value for a particular day in a specific habitat. Same procedure was repeated consecutively over a 7 days period to generate seven replicate values. Sunlight duration was monitored in-situ using Campbell stokes for seven (7) days consecutively according to the methods of Owczarek and Malinowska (2023). The mean from the seven determinations was recorded against each habitat as its sunlight duration.

Statistical Analysis

Mean values obtained from replicate determination of micro-habitat variation (altitude, light intensity and sunlight duration) and Quantitative foliar anatomical details (number and type of stomata and epidermal cells present) based on habitat differences were subjected to inferential statistics. Two-way ANOVA was employed in analysis the means and significant differences in the means were identified using Least Significant Difference (LSD) test (Ubom, 2006). The probability level was set at $P<0.05$. The association between the micro-environmental (ecological) variables and the species quantitative anatomical indices were traced using Karl Pearson Correlation Analysis. Positive correlation coefficients between pairs of variables implied a direct relationship in which both parameters increased together while negative coefficients otherwise implied an inverse relationship in which one parameter increases with a corresponding decrease in the other (Mbong *et. al* 2020b). All statistical analyses were carried out using the SPSS software package, version 20 (IBM Corporation, USA).

RESULTS AND DISCUSSION

Table 1 reveals the nature of habitats in which these ferns inhabit. It shows that the plants could exist either as an epiphyte, lithophyte or as an erect fern. Similarly, Table 2 and 3 gives a description of qualitative and quantitative anatomical characteristics respectively of the studied ferns.

Table 4 states the ecological dynamics of plants habitats. It reveals that the shrub epiphyte and tree epiphyte recorded higher and least values respectively for Altitude (10.36m and 8.23m), light intensity (13088 lux and 1045.3 lux) and daily sunlight exposure (8 hours and 2 hours) respectively. Table 5 indicates significant relationships existing between ecological parameters in the habitats and the anatomical indices of plants. Clearly, there is significant strong positive interrelationships existing between Altitude and light intensity (r= 0.987*; P<0.05) as well as sunlight duration (r= 0.990**; P<0.01) respectively. Also, light intensity correlated significantly with sunlight duration (r= 0.958). Generally, the stomatal types correlated strongly (r= 0.570 – 0.769) with the three habitat parameters while stomatal index correlated strongly and inversely with Altitude (r= - 0.505) and sunlight duration (r= - 0.553). Similarly, sunlight duration correlated moderately and inversely with stomatal number (r= - 0.562).

Table 1: Geographical coordinates and Fern Habitat Feature

	Longitude	Latitude	Habitat description
Lithophyte	7:58':33.2328"	4:39':28.2348"	Dry exposed concrete surface behind a building.
Epihyte (Shrub)	7:58':37.0992"	4:39':22.7628"	Fully exposed shrub branches supporting the fern.
Epiphyte (Tree)	7:58':35.6664"	4:39':23.5368"	Hard, dry bark of a tree fully shaded with a thick broad crown coverage.
Erect	7:58':33.2256"	4:39':28.3068"	Firm moist soil under a low yellow bush hedge and is partially shaded.

Table 2: Habitat-related Foliar (abaxial) Anatomical variations of Studied Fern

	Epidemal Cell (Shape)	Nature of Stomata	Trichomes	Nature of Trichomes	Other information
Lithophyte	Sinuous in shape with undulating anticlinal walls	Diacytic, anisocytic	Absent	-	Present of oil droplets in linear and cluster forms.
Epiphyte (Shrub)	Irregular with undulating anticlinal walls	Diacytic, anisocytic anomocytic	Present	Unicellular trichomes	Present of oil droplets in form of clusters
Epiphyte (Tree)	Irregular with undulating anticlinal wall	Diacytic, anisocytic	Present	Unicellular trichomes	Absent of oil droplet
Erect	Wavy to sinuous anticlinal wall	Diacytic, anisocytic	Absent	-	Present of oil droplets in form of clusters

Table 3: Mean (±S.E.) values of Quantitative Anatomical variations in Studied Fern

	Stomatal Number	Stomatal types	Number of epidermal cells	Stomatal index (%)
Lithophyte	11.33±15.28	2±0.00	76.67±15.28	12.875±1.10
Epiphyte (Shrub)	13.00±2.00	3±0.00	73.00±4.58	15.116±2.30
Epiphyte (Tree)	14.33±1.15	2±0.00	68.33±3.51	17.337±3.00
Erect	8.67±0.58	2±0.00	46.33±4.04	15.764±1.21

*Values are mean (±S.E) obtained from seven replicate plant samples

Table 4: Habitat-based Ecological Heterogeneity in Study Area

	Altitude (meters)	Light Intensity (lux)	Daily Sunlight Duration (Hours)
Lithophyte	9.449±0.82	6201.0±120	6.2±2.00
Epiphyte (Shrub)	10.36±0.13	13088.0±670	8.4±1.45
Epiphyte (Tree)	8.23±0.14	1045.3±48	2.0±0.40
Erect	9.75±1.25	8786.3±117	7.1±1.10

*Values are mean (±S.E) of seven replicate determinations

Table 5: Correlation Matrix showing Habitat-variation and Anatomical parameters of Fern

	Altitude	Light Intensity	Sunlight Duration	Stomatal Number	Stomatal Types	Epidermal Cells count	Stomatal Index
Altitude	1	0.987*	0.990**	-0.447	0.679	-0.065	-0.505
Light Intensity		1	0.958*	-0.353	0.769	-0.073	-0.374
Sunlight duration			1	-0.562	0.570	-0.139	-0.553
Stomatal Number				1	0.319	0.711	0.341
Stomatal Types					1	0.339	-0.057
Epidermal Cells						1	-0.418
Stomatal Index							1

(*) Significance at P< 0.05; (**) P<0.01

Erect fern: Foliar epidermal descriptions of the terrestrial fern are illustrated in Fig. 2 A and B. The epidermal cells on both surfaces (abaxial and adaxial) are largely irregular in shape with undulating anticlinal walls. The walls are several layers thick. The species is hypostomatic having stomata on the abaxial surface only (Figure 2 A), and they are evenly distributed. The mean distribution of stomata and epidermal cells at magnification of X10 are 11.33±15.28 and76.67±15.28 respectively. Trichome is absent on both surfaces and oil droplets are present only on the adaxial epidermal surface appearing in linear and cluster forms (Figures 2 A and B; Tables 3 and 4).

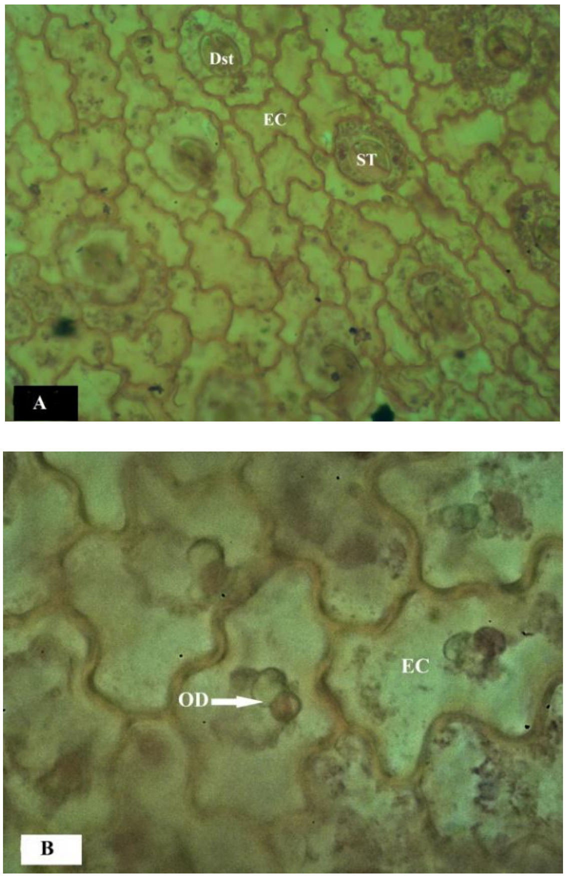


Fig. 2: Epidermal surfaces of terrestrial fern. A: Abaxial and B: Adaxial

Dst: Diacytic stomata; EC: Epidermal cell; ST: Stomata; OD: Oil droplet

Shrub epiphyte: The leaf epidermal descriptions of shrub epiphyte are illustrated on Figure 3 C and D. The abaxial and adaxial surfaces of the leaf epidermis are characterised largely by irregular shaped epidermal cells, having undulating anticlinal cell walls. Hair-like appendages and multicellular uniserriate trichomes are sparsely distributed on the abaxial surface and absent on the adaxial surface. Different types of stomata are present namely, diacytic, anisocytic and anomocytic (Fig. 2 C). Diacytic stomata are present in abundance. The species is hypostomatic. The mean distribution of stomata and epidermal cells at magnification of X10 are 14.33±1.154 and 68.33±3.512 respectively. Oil droplets are present on both surface in linear and cluster form, and are sparsely distributed (Tables 3 and 4).

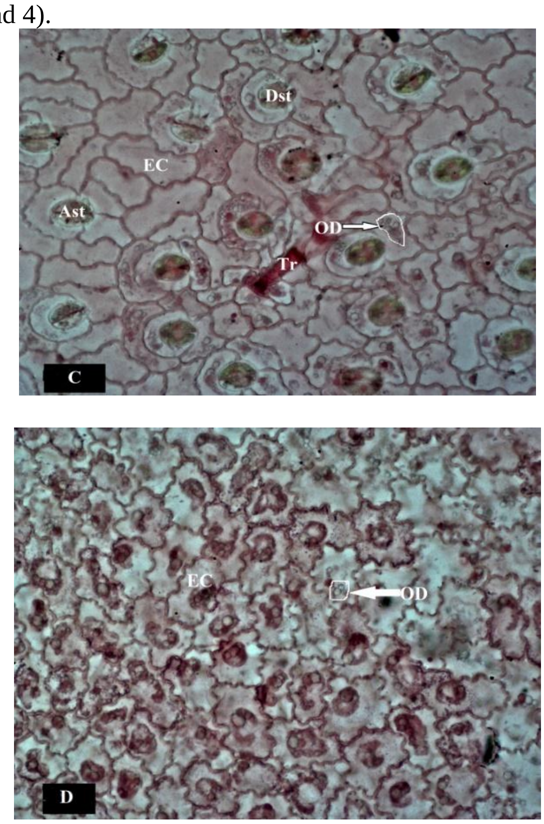
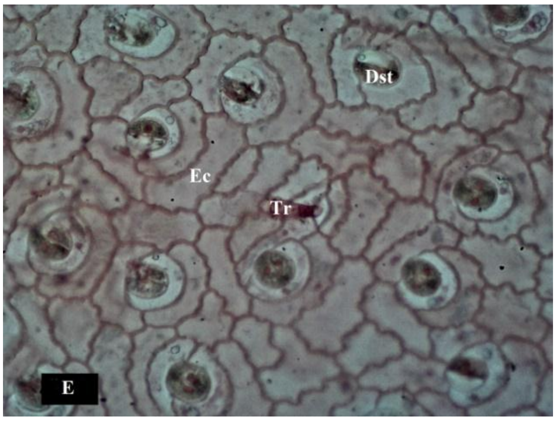


Fig. 3**:** Epidermal surfaces of Shrub Epiphyte. C: Abaxial and D: Adaxial

Dst: Diacytic stomata; EC: Epidermal cell; ST: Stomata; OD: Oil droplet; Tr: Trichome; Ast: Anisocytic stomata

Tree epiphyte: The foliar epidermal descriptions are shown in Figure 4 E and F. The epidermal surfaces of the leaf are characterized by irregular shaped epidermal cells having thick undulating anticlinal cell walls. Two types of stomata are present, namely, diacytic and anisocytic, which are found only on the abaxial surface and absent on the adaxial surface. The mean distribution of stomata and epidermal cells at magnification of X10 are 13.00±2.000 and 73.00±4.583 respectively. Multicellular uniserriate trichomes are present and sparsely distributed on the abaxial surface only. Oil droplet is absent on both surfaces (Tables 3 and 4).



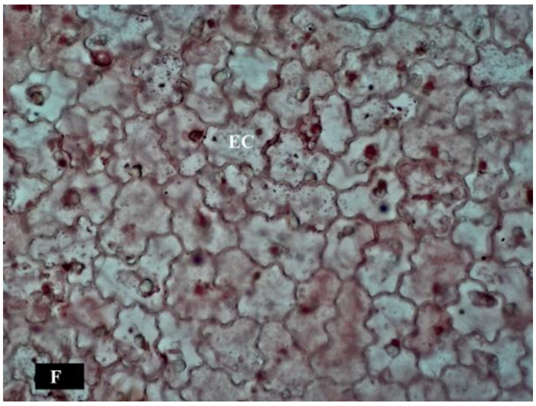
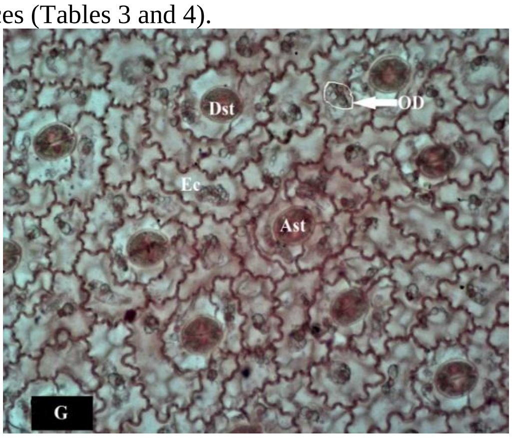


Fig. 4: Epidermal surfaces of Tree Epiphyte. E: Abaxial and F: Adaxial

Dst: Diacytic stomata; EC: Epidermal cell; Tr: Trichome

Lithophyte: Irregular shaped epidermal cells with characteristic wavy to sinuous anticlinal cell wall are unique to both epidermal surfaces of the leaf as showed in Figure 5 (G and H). The leaf is hypostomatic. Stomatal types found are; diacytic and anisocytic. The mean distribution of stomata and epidermal cells at magnification of X10 are 8.67±0.577 and 46.33±4.041 respectively. Trichome is absent on both surfaces. Oil droplets are present, appearing in cluster form and they are abundantly distributed on both surfaces (Tables 3 and 4).



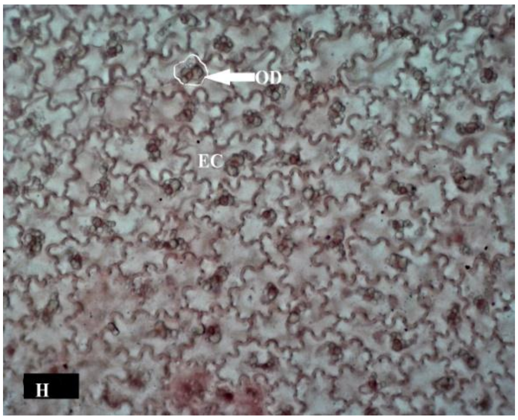


Fig. 5**:** Epidermal surfaces of Lithophyte: E: Abaxial and F: Adaxial

Dst: Diacytic stomata; EC: Epidermal cell; OD: Oil droplet; Ast: Anisocytic stomata

Fig. 6: Lithophytic form growing on concrete base.

Fig. 7: Erect form growing on moist bare soil under walkway hedge.

Fig. 8: Epiphytic form growing on a shrub

Fig. 9: Epiphytic form growing in a tree crevice

DISCUSSION

The present study has demonstrated that the *P. scolopendria* exist and thrive as a lithophyte, epiphyte and as an erect fern. This confirms the views of previous researchers who confirm that the fern may either be epiphytic or erect (Sujatha *et al.,* 2018). Epidermal anatomical features of the species morphotypes are diagnostic and these attributes may be useful for taxa characterization and delimitation. Also, visible similarities among taxa in terms of hypostomatic nature of fronds and the occurrence of diacytic and anisocytic stomatal within the foliar epidermis as a common feature of the four fern variants confirm a close intra-specific relationship and evolutionary affinity of studied plants. This observation tangles with the findings of Akcin and Binzet (2010) that foliar anatomy of plants can provide variety of anatomical features with notable taxonomic significance. On the other hand, the salient anatomical differences noted here seem indicative of possible delimitation of taxa on the basis of species adaptability to inherent factors prevailing in their specific habitats. For instance, the abaxial and adaxial epidermal surfaces of three morphotypes namely; terrestrial fern, Shrub epiphyte, and tree epiphyte are characterized by irregular shaped epidermal cells possessing undulating anticlinal wall while lithophytic variants possess irregular shaped epidermal cells with wavy to sinuous anticlinal walls. Also, there are differences in forms and distributions of oil droplets occurring in lithophyte, shrub epiphytes and erect forms of the ferns but absent in the tree epiphyte. Furthermore, the presence of non – glandular, uniserriate, multicellular trichomes on the abaxial surfaces of tree epiphytes and shrub epiphyte delimit them from lithophyte and terrestrial ferns which do not possess any hair-like appendages. In tandem with previous studies in some other genera, foliar anatomical characters have been employed as useful taxonomic tools for taxa delimitation (Oloyede *et al.,* 2011; Paul and Chowdhury 2021). Our result confirms the existence of *Phymatosorus scolopendria* within the study area as a fern with markedly contrasting habitat features. This observation is synonymous with the reports of Sujatha *et al.* (2018) that the plant may be found either as an epiphyte surviving in the crown of shrubs, on trunk of other plants and on rocks at low to moderate altitudes. Notably, the hypostomatous nature of the ferns is well noticed and clearly understood. This feature has been implicated by previous researchers as an adaptation to checkmate water loss. This correlates with the findings of Goldschmidt (1996) and Ogundare and Saheed (2012). This trend of accentuated response of the species micro-environmental factors revalidates the findings of Hegazy, *et al.* (2010) and Bano *et al*. (2019). Succinctly, each distinct combination of ecological factors creates a micro habitat scenario which may be stress related and in which case levy the members of the incumbent population to develop tactical adjustments in anatomical parameters including epidermal micro characters; stomatal number, epidermal cell shape and size, stomatal types, stomatal index, cellular inclusion etc to help them survive, make up or cushion the effects of environmental imbalance

Our evidence reflects that light intensity, altitude, and duration of sunlight differed significantly ($P<0.05$) across studied habitats and notably, the combinations of these variation constitute a unique set of environmental conditions to which the ferns are exposed to (Taiz *et al.* 2015). Synchronously, the intensities and combination of different abiotic factors in a particular habitat either occur at optimum levels or constitute stress to plants. By the opinion of Shao *et al.* (2008), the environmentally induced stress triggers corresponding anatomical and morphological responses which aids plant survival. Shao, *et al.* (2008) maintained that plants in line with their sessile disposition, exhibit visible flexibility in their metabolic routines to accommodate stressful state through the development of anatomical adaptive responses mediated by environmental gradient which often oscillate predictably and habitually over daily and seasonal rounds. This underscores the orchestrated presence or absence of some key anatomical features oil droplets, trichomes in specific taxa taken from similar or different habitats. For instance, our results confirmed the presence of trichomes only in the epiphytic forms which were growing under shady and occasionally moist substrates. Not just that the trichomes were present in the epiphytes but also, the density of trichomes found was more in the tree epiphyte which seemed the most challenged in terms of moisture availability and light exposure when compared with the shrub epiphytes. The tree epiphytes found on higher altitudes, completely shaded ambience and rooting within deep cracks and crevices of trees growing high above the ground beyond the reach of soil waiter and even rain water splashes from the ground unlike the shrub epiphyte with was closer to the ground. This coordinated fluctuation in the presence and number of trichomes in the ferns from these habitats seems an adaptation for water conservation and enhanced plant water use efficiency. This observation is consistent with Galdon-Armero *et al.*, (2018).

The information from the correlation matrix gives insight towards understanding the ecological reinforcements within the habitats leading to the anatomical adjustments in the species. Clearly, the correlation matrix inferred strong positive and significant relationships existing between the altitude, light intensity and sunlight duration indicates that these parameters vary together such that an increase in one result in a corresponding increase in the other (Mbong *et al*. 2020b). Grossly, within the context of this study, these ecological parameters yielded moderate inverse relationships with number of stomata as well as stomatal index. This trend confirms that taxa showed a monotonous decline in stomatal density with increasing light intensity and prolonged solar irradiation.

The matrix posits that the plants stomatal development is clearly related with variations in light intensity, moisture availability and altitude variations across the habitats. Possibly, the reduction in stomatal densities with increasing solar radiation hours is an adaption to avert or survive water stress since high and prolonged solar irradiance correlates with rapid and high transpiration rates. In the light of this, it is not unexpected for the plants to record lower number of stomata, fewer stomatal types and decreased stomatal index as anatomical adjustment. This observation verifies the views of Bertolino *et al.* (2019) who opined that plant stomatal development may be adjusted with stomatal size and density clearly adapted to match prevailing or changing environmental conditions. Researchers have listed the ecological drivers of such changes to include air temperature, atmospheric CO_2 amounts, light intensity, relative humidity etc (Mott, 2009; Assmann and Jegler, 2016 and Bertolino *et al*. (2019). Furthermore, the stomatal modulations observed within the population is a reflection of lingering external water deficit conditions in some habitats perceived and tolerated by old mature fronds which induce systemic support responses and signals including reduced hydraulic conductance and release of abscisic acid which ultimately give birth to visible stomatal inflections on the new epidermis (Schroder *et. al*. 2001; Mustili, 2002, Tombezi, 2015).

Conclusion and Recommendation

The study was conducted to assess the influence of habitat variation on anatomical features of *Phymatosorus scolopendria* in a peri urban location in Eket. The plant was found present in four different habitats viz: on concrete surface, tree bark, shrub trunk and the ground. From the results, there exist significant ($P<0.05$) microhabitat ecological variation (altitude, light intensity and daily sunlight duration) existing within the contrasting habitat formations. As expected, there were qualitative and quantitative habitat-related variations observed in the foliar anatomical parameters (stomatal index, stomatal types, number of epidermal cells and number of stomata) between the studied morphotypes. The findings confirm that the species is hypostomatic and possess mostly two stomatal types (diacytic and anisocytic) though anomocytic stomata were rarely found in the shrub epiphyte. Only the lithophytic and erect forms possessed unicellular trichomes. Generally, the stomatal number increased in association with habitats bearing prolonged solar radiation and high light intensities. The terms of the current research conclude that the studied ecological parameters to a large extent significantly (at $P<0.05$ and $P<0.01$) correlated with plant anatomical features. The strength and nature of relationships leave imprints suggestive that the visible plants anatomical variations in members of the studied population were related to water stress; hence these anatomical gaps seem a mediation aiding water use optimization and survival across different habitat scenarios. Further more in line with this observation, future research efforts should be geared toward understand the role of this Soil (substrate) and other habitat related dynamics affect the plant morphological and phytochemical properties in contrasting habitat formations. This may further shape the ornamental and ethno- medicinal utilization of plant.

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