DIVERSITY AND DISTRIBUTION OF FERNS ON THE CAMPUS OF THE KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KNUST), KUMASI, GHANA

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ABSTRACT

Identification and distribution of fern species on the Kwame Nkrumah University of Science and Technology campus were determined. A dichotomous key was constructed for the identification of ferns on the Kwame Nkrumah University of Science and Technology campus. The species were identified using keys, descriptions, pictures, figures, herbarium specimens and assistance of fern taxonomists. The distribution of the species was determined using the relative frequency. The relative frequency of the species was quantified by recording the presence or absence of the plant species in a set of ten randomly located quadrats (4 m x 4 m). The plot size in each site was 40 m x 40 m. Thirteen different fern species belonging to the following genera were identified: Nephrolepis, Pteris, Microsorum, Cyclosorus, Arthropteris, Thelypteris, Adiantum, and Pityrogramma. The family Pteridaceae was the most diverse in terms of species richness while the family Oleandraceae recorded the lowest number of species. The most widely distributed fern species were Arthropteris orientalis and Thelypteris microbasis. The distribution of the rest of the species was however low. The study also showed that ferns on the Kwame Nkrumah University of Science and Technology campus are distributed in two main habitats: open and shaded. More of the species occurred in the shaded habitats. The diversity and distribution of ferns were affected by human activities.

Keywords: *Diversity, ferns, distribution, KNUST, dichotomous key.*

INTRODUCTION

Ferns are non-flowering plants with large leaves called megaphylls that reproduce by spore formation (Allen, 1999). There are about 10400 known species of ferns in the world (Allen, 1999). The American Fern Society puts the figure at about 12,000 species (Anonymous, 2004), while the Royal Botanic Gardens, Kew has recorded about 11,000 fern species representing 318 genera and 36 families (Anonymous, 2000). The largest genera in the fern group are *Asplenium*, with 900 species, and *Adiantum* and *Cyathea* with 700 species each. Family dominance has been observed for the fern families with Dryopteridaceae (1,100 species) and Thelypteri-

daceae (950 species) dominating (Anonymous, 2000).

Ferns grow in many different habitats around the world but are especially abundant in tropical rainforests (The Columbia Encyclopaedia, 2001), where temperature, light and humidity are favourable. As a group, ferns thrive best in moist, shady environments, although a few inhabit rock surfaces (Bold, 1977). Some hardy species can, however, occur in drier areas (Stern, 1997). The greatest diversity of fern species occurs in the tropics where they constitute an average of 7% of all vascular plant species of rainforests (Anonymous, 2000). Roughly, 70% of ferns are found in tropical climates, while the remaining 30% occur in temperate climates (Allen, 1999).

The complexity and difficulty of the classification of ferns is very obvious as after more than two centuries of work, the arrangement of species into genera and genera into families is still not settled, with almost every new treatment adopting a different system of classification (Croft, 1999). This is evidenced by great name changes in fern taxa at all levels. This might be largely due to great diversity in the form and structure of ferns, such that it is not possible to name one character which is diagnostic of the group (Sporne, 1970).

Roux (2001) has listed about 82 different species of ferns from Ghana. These belong to 41 genera and 20 families. Prominent among the families are Pteridaceae (14 species), Aspleniaceae (14 species), Tectariaceae (8 species), Polypodiaceae (7 species), Thelypteridaceae (5 species), Hymenophyllaceae (5 species), Lomoriopsidaceae (5 species), Oleandraceae (4 species), and Nephrolepidaceae (3 species). On the KNUST campus many ferns are found in two habitats. However, only four species have been identified in previous works (cf. Afulani, 1996: Attah, 1997).

Ferns show a lot of diversity in their practical uses. They are normally used for food, medicinal, economic, decorative, and environmental purposes in many countries including United States, Europe, New Zealand, Japan, Africa and the Philippines (Allen, 1999). In spite of their multipurpose use, ferns are a group of plants which are relatively less known compared to higher vascular plants. Information on the diversity, distribution and ecology of ferns remains extremely scarce and incomplete (Kornaś, 1979). The identification of ferns has been an old age problem partly due to lack of identification keys for fern species. This study attempted to identify the species of ferns at the Kwame Nkrumah University of Science and Technology campus, determine their distribution, and construct a dichotomous key for easy identification of the ferns.

MATERIALS AND METHODS

Study area

The study was undertaken at the Kwame Nkrumah University of Science and Technology in Kumasi, Ghana. The Kwame Nkrumah University of Science and Technology used to be a typical rainforest but with the increasing rate of development coupled with population increase there is fast deforestation of the forest. The vegetation of the Kwame Nkrumah University of Science and Technology is classified as a semi-deciduous forest with relatively high amount of annual rainfall. The total annual rainfall is about 731 mm while the average annual minimum and maximum temperatures are 21.55°C and 32.12°C respectively. The average annual humidity in the area is 599.2%. Some of the study sites are marshy or swampy and easily become flooded during the rainy season. These areas are dominated by a few plant species that have the ability to thrive in such conditions.

Small scale farming activities occurred in some parts of the study area. These farming activities coupled with hunting have affected the number and distribution of plant species at the study area. Ten different sites were identified to harbour fern species.

Selection of sampling sites

For convenience and easy sampling of species, the study area was stratified into two main zones: (1) high canopy shaded areas, and (2) open areas. The first zone had more shade because of high canopy cover. It included areas such as the underside of bridges. The second zone was further subdivided into three areas: a) settlement areas b) cultivated areas, and c) uncultivated areas. Four sites were selected for sampling in the shaded zone, while six sites were selected for sampling in the open zone. Two sites were sampled in each of the subdivided areas in the open zone. Another important factor was that most of the open areas were marshy or swampy, and were more often cultivated into sugarcane and cocoyam farms. There were also isolated portions of the shaded areas which were swampy or marshy.

The study was undertaken from January 2003 to February 2004.

Habitats of the fern species

The ferns were distributed in two main habitats. These were open and shaded habitats. The open habitat was greatly deforested and characterized by sparse trees with moderate shrubs and dense cover of grass. Vast areas of this habitat type had been cultivated, and developed for human settlement. Furthermore, most of the sites studied in the open habitat were marshy or swampy. The shaded habitat on the other hand was characterized by much more trees that covered the ground vegetation of sparse shrubs, herbs and grasses. The vegetation of the shaded habitat is classified as semi-deciduous forest. The trees found in the habitat provided a much more canopy cover for the vegetation beneath. The shaded habitat also included the underside of bridges, where there was much shade. The understory vegetation of the shaded habitat did not receive direct sunlight as the sunlight was filtered by tree canopies. Some of the areas did not receive sunlight at all.

Identification of the ferns

Identification of the ferns was done using keys, descriptions, herbarium specimens (from Kew Botanic Gardens herbarium, the Kwame Nkrumah University of Science and Technology herbarium, and the Ghana Herbarium, University of Ghana), figures, and pictures as well as the assistance of fern taxonomists. Morphological and anatomical features of taxonomic interest of the specimens recorded on the field also aided the identification process. Voucher specimens were kept at the Kwame Nkrumah University of Science and Technology herbarium in the Department of Theoretical and Applied Biology. The classification used in this study was that of Tryon and Lugardon (see Roux, 2001).

Relative frequency determination

Relative frequency was used to determine the distribution of the species (Odunfa, 1991). The relative frequency of the species was quantified by recording the presence or absence of the plant species in a set of ten randomly located quadrats (2m x 2m) (Green *et al.*, 1995). The plot size was 40m x 40m. The presence or absence of the species in the quadrats was recorded. The frequency and relative frequency of each species were calculated as follows:

$$\text{Frequency} = \frac{\text{Number of quadrats with species X}}{\text{Total number of quadrats used}} \times 100\%$$

$$\text{Relative frequency} = \frac{\text{Frequency of species X}}{\text{Sum of frequencies of all species}} \times 100\%$$

Identification key for ferns on the KNUST campus

Identification key was developed for the identified fern species using the taxonomic features recorded for the species on the field. The identification key constructed was dichotomous.

RESULTS

Diversity of ferns on the KNUST campus

The fern species identified at the study area together with their families are shown in Table 1. The collector name, collection numbers, and dates of collection are provided in the table. Thirteen species belonging to 8 genera and 5 families were identified.

Table 1: A list of fern species and their distribution in the families on the Kwame Nkrumah University of Science and Technology campus

Species	Family	Collector name	Collection number	Collection date
Pteris quadriaurita Hook.	Pteridaceae	P. Addo-Fordjour	0103	7/1/2003
Pteris atrovirens Willd.	Pteridaceae	P. Addo-Fordjour	0203	22/01/03
Adiantum fergusonii	Pteridaceae	P. Addo-Fordjour	0303	7/1/2003
Adiantum cunninghamii Hook.	Pteridaceae	P. Addo-Fordjour	0403	21/02/03
Pityrogramma calomelanos (L.) Link.	Pteridaceae	P. Addo-Fordjour	0503	11/4/2003
Nephrolepis undulata (Afz. ex Sw.) J. Sm.	Nephrolepidaceae	P. Addo-Fordjour	0603	28/01/03
Nephrolepis biserrata (Sw.) Schott.	Nephrolepidaceae	P. Addo-Fordjour	0703	11/6/2003
Nephrolepis exaltata (L.) Schott.	Nephrolepidaceae	P. Addo-Fordjour	0803	30/05/03
Microsorum scolopendria (Burm.f.) Copel.	Polypodiaceae	P. Addo-Fordjour	0903	14/11/03
Microsorum punctatum (L.) Copel.	Polypodiaceae	P. Addo-Fordjour	1003	14/11/03
Thelypteris microbasis (Baker) Tardieu	Thelypteridaceae	P. Addo-Fordjour	1103	3/7/2003
Cyclosorus afer (Christ.) Ching.	Thelypteridaceae	P. Addo-Fordjour	1204	19/02/04
Arthropteris orientalis (J.F.Gmel.) Posth.	Oleandraceae	P. Addo-Fordjour	1303	11/4/2003

Distribution of fern species

The distribution of fern species on the Kwame Nkrumah University of Science and Technology campus is represented in Figure 1. *Arthropteris orientalis* and *T. microbasis* were the most widely distributed fern species in the study sites forming 45 % of all the ferns identified. The species that showed low distribution were *Pteris quadriaurita*, *Microsorum punctatum*, *Pteris atrovirens*, *Adiantum fergusonii*, *Pityrogramma calomelanos*, *Microsorum scolopendria*, *Nephrolepis undulata*, *Adiantum cunninghamii*, *Nephrolepis exaltata* and *Cyclosorus afer*, forming between 2 % and 8 % of the population. More species (about 38.5%) were distributed in the family Pteridaceae, while the family

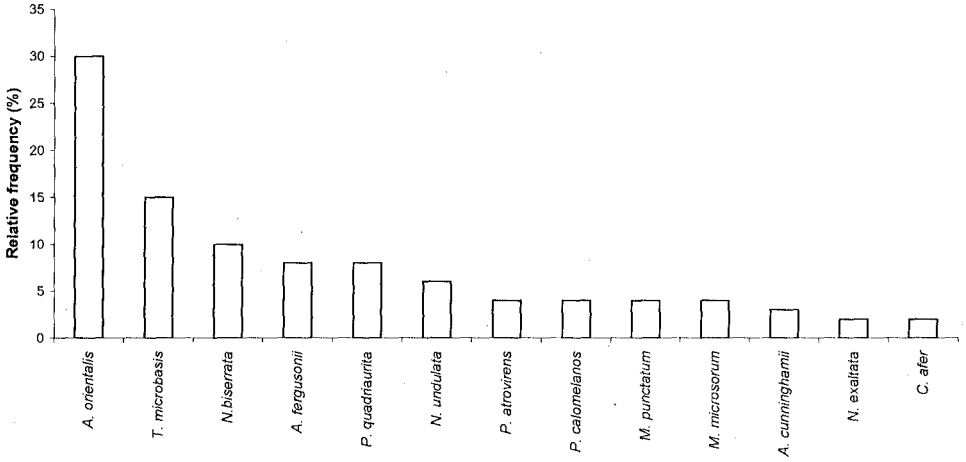

Fig. 1. Distribution of fern species on the campus of the Kwame Nkrumah University of Science and Technology

Oleandraceae recorded the lowest distribution of species (about 7.7%) (Table 1).

The species were distributed in two main habitat types: the shaded and the open (Table 2). More species (about 61.5%) occurred in the shaded habitat than in the open habitat (about 38.5%).

Identification key for ferns on the Kwame Nkrumah University of Science and Technology campus

Fig. 2 is the dichotomous key constructed for all the thirteen fern species identified on the Kwame Nkrumah University of Science and Technology campus. It required an average of four steps to separate a species which makes it very easy to be used. The legend for the identification key is given in Table 3.

DISCUSSION

Diversity and distribution of ferns on the Kwame Nkrumah University of Science and Technology campus

In the present study thirteen fern species were identified. Out of this number six fern species namely *Pteris atrovirens*, *Pityrogramma calomelanos*, *Nephrolepis biserrata*, *Microsorum scolopendria*, *Microsorum punctatum*, and *Arthropteris orientalis* are found in the list of fern species in Ghana provided by Roux (2001). Previous works by Afulani (1996) and Attah (1997)

Table 2: Distribution of fern species in the habitats

Species	Habitat
Arthropteris orientalis	Terrestrial. Grows in exposed (open) areas. Common in Swampy and/or marshy environments.
Nephrolepis undulata	Terrestrial and epiphytic. Grows in open habitats, on dry soils. Common in both cultivated and settlement areas.
Nephrolepis exaltata	Terrestrial and epiphytic. Grows in shaded areas.
Nephrolepis biserrata	Terrestrial and epiphytic. Grows in moist, deeply shaded environments
Microsorum scolopendria	Terrestrial and epiphytic. Grows on dry soils, in the open. Common in uncultivated areas.
Microsorum punctatum	Terrestrial and epiphytic. Grows in moist, deeply shaded areas.
Cyclosorus afer	Terrestrial. Grows around farms edges (cultivated) in the open.
Pteris quadriaurita	Terrestrial. Grows in moist, deeply shaded areas especially the underside of bridges.
Pteris atrovirens	Terrestrial. Grows among shrubs in the open.
Adiantum fergusonii	Terrestrial. Grows in moist, deeply shaded areas especially the underside of bridges.
Adiantum cunninghamii	Terrestrial. Grows in deeply shaded areas.
Pityrogramma calomelanos	Terrestrial. Grows in deeply shaded areas; underside of bridges, among trees in the forest.
Thelypteris microbasis	Terrestrial. Grows in shaded areas. Common in cultivated and/or marshy environments.

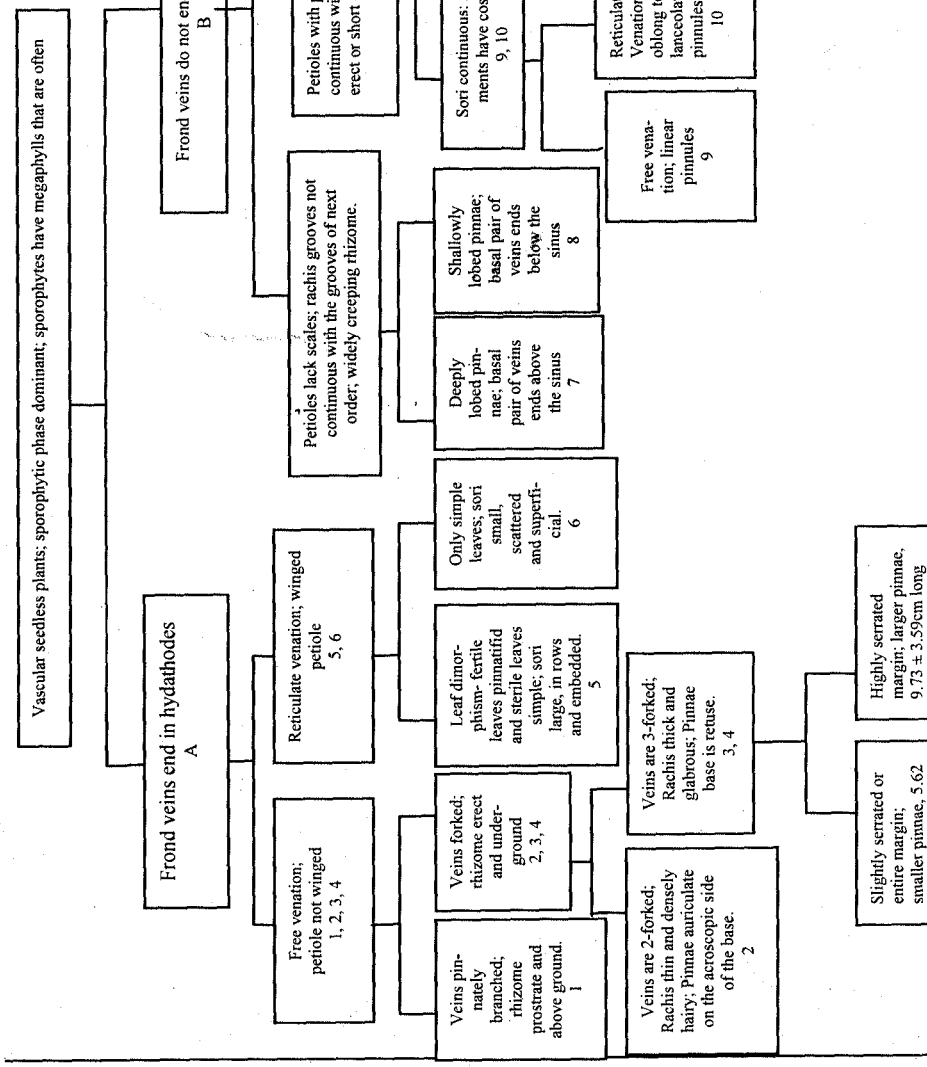

Figure 2: A dichotomous key for fern species on the Kwame Nkrumah University of Science and Technology campus

Table 3: Legend for dichotomous key of ferns at the Kwame Nkrumah University of Science and Technology campus

Number	Species	Features
1	*Arthropteris orientalis*	A
2	*Nephrolepis exaltata*	
3	*Nephrolepis undulata*	Ferns with hydathodes in the frond veins
4	*Nephrolepis biserrata*	
5	*Microsorum scolopendria*	
6	*Microsorum punctatum*	
7	*Thelypteris microbasis*	
8	*Cyclosorus afer*	B
9	*Pteris quadriaurita*	
10	*Pteris atrovirens*	Ferns without hydathodes in the frond veins
11	*Pityrogramma calomelanos*	
12	*Adiantum fergusonii*	
13	*Adiantum cunninghamii*	

identified four fern species on the Kwame Nkrumah University of Science and Technology campus. Of the four species identified by these workers, only two namely *Nephrolepis undulata* and *Arthropteris orientalis* were found in this study. Perhaps the absence of the other two species could be due to habitat loss as a result of human occupation and deforestation, or to a number of other factors such as fire, soil fertility, and rainfall which affect diversity of ferns (Kornaś, 1979; Lwanga *et al.*, 1998). The increasing rate of development coupled with farming activities have resulted in habitat disturbances. Such occasional severe or frequent low habitat disturbances may affect species diversity (Chapman and Reiss, 1995). The clearing of the vegetation for infrastructural expansions and farming has greatly modified the once close canopy. Most of the Kwame Nkrumah University of Science and Technology campus is now characterized by very large gaps or openings dominated by grass and shrubs. Ferns thus do not receive the natural protection offered by canopy covers (Watt, 1976) against the potential negative effects on the plants including evapotranspiration.

The most widely distributed species were *Arthropteris orientalis* and *Thelypteris microbasis*. Each of the species formed several monotypic stands in some parts of the study area. These species are invasive weeds and are able to establish themselves very well in disturbed habitats (Perrings *et al.*, 2002). They were mostly found in disturbed areas such as farms and settlement areas. This finding may be an indication of the extent of disturbance in the study area. The species have very wide creeping rhizomes with lateral branches (Croft, 1999; Roux, 2001) which enable them to spread over a wide area after

establishing themselves. Furthermore, these ferns have a strong preference for marshy environments and are known to grow best in such areas. Greater number of the study sites was marshy and thus provided favourable habitats for the species to thrive. This condition also prevented the fern species from the effect of frequent fire by hunters and farmers. This finding is supported by the findings of other studies examining the effects of fire on Pteridophyte distribution (Kornaś, 1979).

The distribution of the other species was low. Unlike *Arthropteris orientalis* and *Thelypteris microbasis*, the other species are delicate (Dunne and Eisenbeis, 1978) and easily succumb to environmental pressure. The distribution of these species might have therefore been influenced by habitat disturbance. The marshy nature of the study area might have also affected their distribution. Though ferns require adequate moisture for proper development and reproduction, too much of it can hinder the growth of many of them. For instance, the maidenhair fern, *Adiantum fergusonii*, was not found in marshy areas since it does not do well in excessive humidity (Perry, 2004). Fire was a factor observed to have affected the distribution of the fern species. The distribution of the fire sensitive species was therefore restricted to areas which were not prone to fire disturbance (Kornaś, 1979).

The study showed that ferns were distributed in two main habitat types namely the shaded and the open. More of the fern species preferred the shaded habitat, making their distribution greater in this habitat. This finding is consistent with the finding that most ferns thrive best in moist shady environments (Bold, 1997; Green *et al.*, 1995). In the shade, the species were protected from direct sunlight (Watt, 1976) leading to a reduction in the potential negative effects on the plants including evapotranspiration. The shade also favours high humidity and therefore high rate of organic decomposition (Molles, 1999), a condition necessary for proper fern development

More fern species were distributed in the family Pteridaceae. This family is one of the largest fern families in terms of species richness, and also has a worldwide distribution. Its species show great diversity in habitats ranging from moist to dry, open to shade and stable to disturbed habitats (Tryon and Tryon, 1982). This could explain the greater species richness in the family recorded in the study. Family Oleandraceae had the lowest number of species. The family has a narrow worldwide distribution. Genus *Oleandra* of the family contains about 73% of the species which are distributed only in Asia (Roux, 2001).

Identification key of ferns on the Kwame Nkrumah University of Science and Technology campus

The identification key constructed for the species was dichotomous. It required an average of four steps to separate a species which makes it very simple and easy to be used. The species were separated according to their taxonomic groupings. Easily observable plant features were considered first before secondary characters. Since the major plant features are macroscopic and easily observable, ferns can easily be grouped on the basis of the features in the key. As much as possible, the feature(s) used at a given stage separated the species into two equal parts (Glen, 2000), a quality of a good identification key.

CONCLUSION

The present study has revealed that ferns on the KNUST campus are distributed in two main habitats; open and shaded. Species diversity of ferns at the shaded habitats was higher than that of the open habitats. The diversity and distribution of ferns were affected by human activities such as farming and hunting.

RECOMMENDATIONS

As much as possible efforts must be made to protect the areas that offer the possible highest contribution of biological diversity in future.

Small scale farmers should be discouraged from farming at such areas while hunters should also be barred from setting fires. Since infrastructural development will continue to be part of the developmental agenda of the Kwame Nkrumah University of Science and Technology, it is important that fern species that are likely to be affected are cultivated in the Kwame Nkrumah University of Science and Technology botanic garden so as to forestall their possible loss.

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