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DIVERSITY AND DISTRIBUTION OF EPIPHYTIC FERNS IN KIBALE NATIONAL PARK, UGANDA

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ABSTRACT. A survey of epiphytic ferns was carried out in logged and unlogged forests of Kibale National Park. The hundred major host trees were studied by a Single Rope Technique. A total of 5 families, 13 genera, and 24 species were found. Aspleniaceae and Polypodiaceae were the most species-rich families at the study sites. The total number of species did not differ significantly between logged and unlogged forests. There was a weak correlation between the basal area of the host and the number of ferns present. Most species were found growing in light humus as compared to bark and heavy humus as substrates. Most species occurred on the base and mid branch zones of their hosts although there was a wide range of vertical distribution in the logged and unlogged forest. The most similar vertical zones relative to species of ferns present were the base and mid branch regions with Jaccard's indices of 0.673 and 0.781 for the unlogged and logged forests respectively. Selective logging appears not to have led to the decline in the species richness and change in the composition of the epiphytic ferns 28 years following that event.

Key words: ferns, substrate, canopy, tropical, forest

INTRODUCTION

This study was conducted to determine the floristic composition and distributions of the epiphytic ferns in logged and unlogged forest plots in Kibale National Park. Observations were also made to identify the ecological factors responsible for these distributions

The increasing trend of logging tropical forests in Uganda threatens the conservation of biodiversity therein. Pteridophytes are a significant component of the vegetation of the tropical rainforests especially in montane cloud forests and in naturally disturbed lowland rainforests. Past surveys have reported 39 species in Nimba Range (Johanson 1974), 27 species in Kilimanjaro (Hemp 2001), and 10 species in Mt. Kenya (Schelpe 1951). The structure and function of vascular epiphytes vary in response to the differences in the amount of light, water availability and substrate requirements (Longman & Jenik 1987, Benzing 1995). Vascular epiphytes have been categorized as holoepiphytes and facultative epiphytes. Holoepiphytes remain free of contact with the ground for life. They can grow on bark or in humus deposits and are restricted to the trunk of woody plants or the canopy as a habitat. Facultative epiphytes grow interchangeably on the ground and on the trunk or canopy. Epiphytes are sensitive indicators of microclimate and provide microhabitats and food for rainforest fauna (Hietz 2005). The copious production and wide dispersal of spores have a vital role in the occupancy of suitable sites (Dassler & Farrar 2001).

Crassulacean Acid Metabolism (CAM) was reported at least in seven species of tropical ferns; in the epiphytes *Drymoglossum piloselloides, Pyrossia longifolia, P. adnascens, P. angustata, Microsorum punctatum,* and *Polypodium crassifolium*; and in the lithophyte *Platycerium veitchii* as a physiological water conserving device (Sinclair 1985, Ong et al. 1986, Holtum and Winter 1999, Wallace 1989).

MATERIALS AND METHODS

Study Area

Kibale National Park includes a medium altitude (1110–1590 m) transitional, moist forest interposed between dry tropical and wet tropical rainforest in the Albertine region (latitude 0°13′–41′N and longitude 30°19′–30°32′E) of Western Uganda (FIGURE 1). The protected area of 766 km^2 was declared a National Park in 1993. Kibale forest covers numerous hills, valleys, swamps, and streams. The rainfall ranges from 1490 mm in the south to 1622 mm in the north and falls in two wet seasons: March to May and September to November (Struhsaker 1997). Mean annual temperature is low (20.5°C) and varies little during the year.

Kanyawara site was sampled in three compartments: 1) compartment K-30 consists of about 300 ha of mature tropical mixed forest. It is disturbed only by the removal of 3–4 large stems/100 ha (Kasenene 1987). Skorupa and Kasenene (1984) reported no evidence that this activity had altered the forest structure and composition. 2) The compartment K-14 supports about 390 ha of secondary forest that was selec-

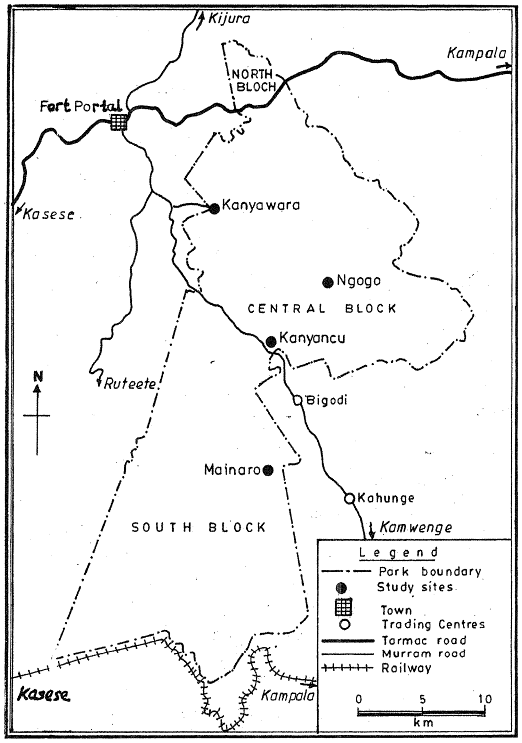

FIGURE 1. Major forest blocks, roads, and approximate location of the study sites in Kibale National Park.

tively cut in 1969 (Kasenene 1987, Skorupa 1988). That harvest was moderate, averaging 14 m^3/ha (saleable volume only), and a 75.1% of forest was left in place (26.7 m^2/ha) (Skorupa 1988). The K-15 compartment includes about 360 ha of forest that was more heavily cut between September 1968 and April 1969 (Kasenene 1987). The total harvest averaged 21 m^3/ha, that means 53.4% left in place (19.0 m^2/ha). The Ngogo study area is located in the southern block of Kibale Forest Reserve that is relatively undisturbed. The results of a timber stock inventory prior to logging show tree density, basal area, forest canopy cover, and species diversity were relatively constant for all subtypes of *Parinari* forest (Kingston 1967, Kasenene 1987).

Floristic Composition Methods

The forest types described earlier (Kanyawara K-30, K-14, K-15, Ngogo, and Kanyancu) were sampled by locating 30 random points within each of the forest types (Usher 1992). Around each point, a mature tree heavily loaded with epiphytes was identified for a detailed sampling of epiphytic ferns. A total of 100 major hosts were identified from a total of 150 points. Hoft and Hoft (1993) observed that random selection of host plants was necessary for adequate data comparisons. A single rope technique was used to access the canopy of host trees (Petzl 1992, Ingram & Lowman 1995). Voucher specimens were collected, dried, and identified at the Makerere University Herbarium by referring to a checklist (Johns 1991). Measurement of the diameter at breast height (dbh) of the host trees was done by a diameter tape. Cluster Analysis (simple-matching coefficient) of the species composition in the forest types were done by PC-ORD-VERSION 4 (McCune & Mefford 1999). Correlation coefficient was calculated using the computer-based program "MSTAT" to establish the relationship between epiphytic ferns and the tree basal area.

Vertical Distribution Methods

The vertical zonal distribution of epiphytes was determined subjectively by subdividing host tree into five zones (Johansson 1974, 1989; Lowman & Nadkarni 1995). They were lower stem (LS), upper stem (US), based branch (BB), mid branch (MB), and top branch (TB) with the last three zones resulting from subdividing the crown into three equal thirds. The similarity of the height zones was determined by Jaccard's coefficients (JI) (Ludwig & Reynolds 1988). The JI ranges from near 0 (for a zone pair highly dissimilar) to near 1 (zone pair very similar). Cluster analysis (simple-matching coefficient) and the species association analysis (group average linkage method) of the similarity between height zones on the basis of fern species in both logged and unlogged forests were done by PC-ORD-VERSION 4 (McCune & Mefford 1999).

Substrate Requirement Methods

Substrate was recorded according to whether the species was on bark, light humus, or heavy humus. The substrate categories were adopted from Benzing (1995). Species growing on bryophyte mats were described as "light humus" users, while those restricted to thick layers of organic matter were described as "heavy humus" users. Cluster analysis (simple-matching coefficient) and the species association analysis (group average linkage method) of the similarity between substrate types on the basis of fern species in the logged and unlogged forests were done by PC-ORD-VERSION 4 (McCune & Mefford 1999).

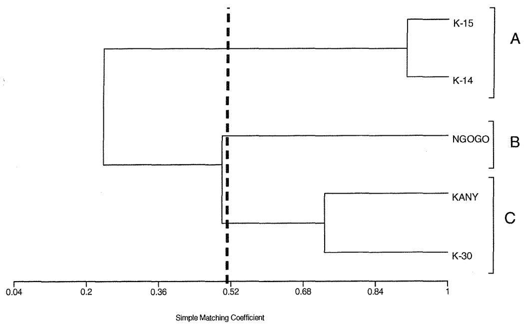

FIGURE 2. Cluster Analysis of the logged (K14 and K15) and unlogged (K30, Ngogo, and Kanyancu) forest types based on epiphytic fern species in Kibale National Park.

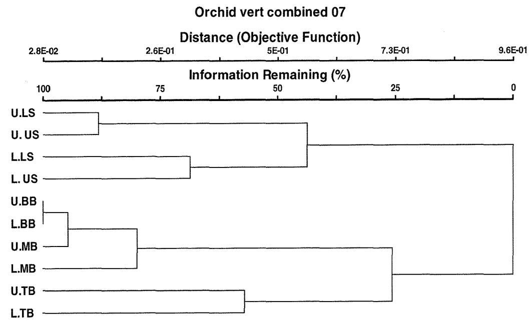

FIGURE 3. Cluster Analysis of the height zones of the host trees based on epiphytic fern species in Kibale National Park in the logged (K14 and K15) and unlogged (K30, Ngogo, and Kanyancu) forests in Kibale National Park. Abbreviations: **Stems** (ULS = Unlogged Lower Stem; LLS = Logged Lower Stem; UUS = Unlogged Upper Stem; LUS = Logged Upper Stem); **Low branches** (UBB = Unlogged Base Branch; LBB = Logged Base Branch); **Mid branches** (UMB = Unlogged Mid Branch; LMB = Logged Mid Branch); **Top branches** (UTB = Unlogged Top Branch; LTB = Logged Top Branch).

RESULTS

Floristic Diversity

Nine out of 24 species were recorded in all the forest types. A total 23 species occurred at Kanyawara. Ngogo had 15 species, while the Kanyancu part of the south block of Kibale had 14 fern species. The most frequent species of ferns in Kibale national park were *Loxogramme lanceolata* (SW.) C.Presl., *Microsorum punctatum* (L.) Copel, *Asplenium theciferum* (Kunth.) Mett., *Platycerium elephantotis* Schweinf, and *Pyrrosia schimperiana* (Mett. *ex* Kuhn) Alston. *Drynaria laurentii* (Christ) Hieron and *Phymatosorus scoloropendria* (Burmf.) Pichi–Serm. were restricted to the south part of the park at Kanyancu. Chi square analyses showed no significant difference in the diversity of epiphytic ferns among the study sites in Kibale National Park. The best represented families were Aspleniaceae and Polypodiaceae with 13 (48%) and 8 (30%) species respectively.

Cluster analysis using epiphytic fern species revealed two groupings: one formed by moderate and heavily logged sites (Kanyawara K14 and K15, respectively) and the second formed by unlogged or almost unlogged sites (Ngogo, Kanyancu, and Kanyawara K30) (FIGURE 2). Logged forests were clustered separately from the unlogged forest on the basis of epiphytic ferns present.

Correlation and regression analyses on the data collected by the canopy-based method revealed a weak positive correlation (r = 0.220, df = 75; t = 4.093, $P < 0.05$, y = 4.69 + 1.46x) between species of ferns and basal area of the host trees.

Vertical Distribution Results

The diversity of ferns increases from the base of the trunk to the mid canopy regions of the host trees, then declines toward the branch ends in both logged and unlogged forest types. The most similar regions in terms of fern species hosted were the mid branch and the base branch, with JI of 0.673 and 0.781 for both the unlogged and logged forests, respectively. Cluster analysis of the logged and unlogged forest data confirmed the observed pattern of similarity (FIGURE 3). Fern species were similar in the same height zones in the logged and unlogged plots.

The fern community rooted on trunk was clearly differentiated from that of the canopy. The most prevalent fern species in the top region were *Pyrrosia schimperiana, Microgramma owariensis* (Desv.) Alston, and *Pleopeltis macrocarpa* (Willd.) Kaulf. (FIGURE 4). The species common in the mid and base branch regions were *Microsorum punctatum* (L.) Copel, *Platycerium elephantotis, Arthropteris monocarpa* (Cordem.) C. Chr., *Asplenium theciferum,* and *Oleandra distenta* Kunze in both the logged and unlogged forest compartments. Most of the other species of ferns were restricted to the trunk regions of the hosts and darker forest conditions, e.g., *Loxogramme lanceolata, Asplenium africanum* Desv., *Microsorum punctatum, Vittaria guineense* Desv., and *Asplenium* species.

Substrate Requirement Results

Cluster analysis of the similarity of the substrate types in both logged and unlogged forest revealed two main groups (FIGURE 5). The first one consisted of the bark-dwelling fern species

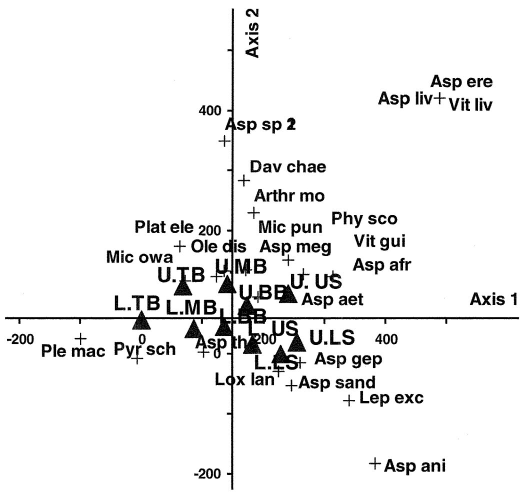

FIGURE 4. Ordination of the epiphytic fern species from height zones of the logged (K14 and K15) and unlogged (K30, Ngogo, and Kanyancu) forests in Kibale National Park.

Abbreviations: **Stems** (ULS = Unlogged Lower Stem; LLS = Logged Lower Stem; UUS = Unlogged Upper Stem; LUS = Logged Upper Stem); **Low branches** (UBB = Unlogged Base Branch; LBB = Logged Base Branch); **Mid branches** (UMB = Unlogged Mid Branch; LMB = Logged Mid Branch); **Top branches** (UTB = Unlogged Top Branch; LTB = Logged Top Branch).

Fern species abbreviations: *Arth mon = Arthropteris monocarpa, Asp aet = Asplenium aethiopicum, Asp afr = Asplenium africanum, Asp ani = Asplenium anisophyllum, Asp ere = Asplenium erectum, Asp gep = Asplenium geppi, Asp meg = Asplenium megalura, Asp sand = Asplenium sandersonii, Asp liv = Asplenium lividum, Asp the = Asplenium theciferum, Dav chae = Davallia chaerophylloides, Lep exc = Lepisorus excavatus, Loxo la = Loxogramme lanceolata, Micr ow = Microgramma owariensis, Micr pun = Microsorum punctatum, Ole de = Oleandra distenta, Plat ele = Platycerium elephantotis, Phyc sco = Phymatosorus scolopendria, Pleo mac = Pleopeltis macrocarpa, Pyr sch = Pyrrosia schimperiana* and *Vitt gui = Vittaria guineensis* and *Vit liv = Vittaria lividum.*

in both logged and unlogged forests. The second group had fern species occurring in both light and heavy humus within which the most similar substrate on the basis of fern species is the light humus in both the logged and unlogged forests. Fern species were similar in the same substrate types in both logged and unlogged plots. Most fern species were found in light humus such as *Platycerium elephantotis, Loxogramme lanceolata, Oleandra distenta,* and *Asplenium* species in the logged and unlogged forests.

The unlogged forest blocks had fern species such as *A. monocarpa, M. owariensis,* and *P. elephantotis* rooted on the bark. *Asplenium africanum, M. punctatum,* and *Davallia chaerophyloides* (Poir.) Steud. dominated the heavy humus substrate. Species like *A. monocarpa* and *M. owariensis* had long-creeping rhizomes growing in the light humus, spreading to the bark substrate. Most of the fern species were rooted in the light and heavy humus substrates. Other species restricted to heavy humus substrates such as *D. chaerophylloides* have a succulent rhizome usually buried in the heavy humus.

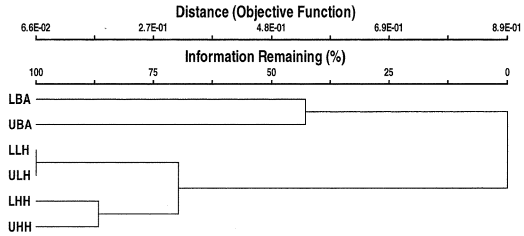

FIGURE 5. Cluster Analysis of the substrate types on the host trees based on epiphytic fern species in Kibale National Park in the logged (K14 and K15) and unlogged (K30, Ngogo, and Kanyancu) forests in Kibale National Park. Abbreviations: **Bark** (L.BA = Logged bark; U.BA = Unlogged Bark); **Light humus** (L.LH = Logged Light Humus; U.LH = Unlogged Light Humus); **Heavy humus** (L.HH = Logged Heavy Humus; U.HH = Unlogged Heavy Humus).

DISCUSSION

Floristic Diversity

The five families of ferns identified in Kibale National Park are the same as those reported by Johansson (1974) for the forest in Nimba ranges in Liberia where Polypodiaceae and Aspleniaceae dominate. In Kibale forest, we cannot detect any significant difference in epiphytic fern diversity between logged and unlogged blocks. However, some ferns such as *Pyrrosia schimperiana, Pleopeltis macrocarpa, Asplenium erectum, Asplenium* sp. 2, and *Platycerium elephantotis* were more common in the logged forests. Overall, epiphytic diversity tended to increase with increasing tree basal area. Increase in basal area possibly increases the surface area for attachment for the epiphytes.

Vertical Distribution Discussion

Most fern species were on the low and mid branches. Kornas (1977) noted that *Asplenium megalura, A. theciferum* var. *conncinum, Loxogramme lanceolata, Vittaria guinneensis, Platycerium elephantotis,* and *Pyrrosia schimperiana* curl up during drought but unfold after wetting. *Microgramma lycopodioides, Oleandra distenta,* and *Pleopeltis excavata* lost the fronds and became dormant during the drought (Kornas 1977). *Pyrrosia schimperiana, Pleopeltis macrocarpa,* and *Microgramma owariensis* were common in the top branches (Luttge 1989).

Ferns that exhibit compact or narrowly creeping rhizomes or bear leaves in tufts such as in *Platycerium elephantotis, Microsorum punctatum,* and *Asplenium theciferum* were common on the branches because of their ability to trap water and litter for nutrients. The root climbing forms have long-creeping rhizomes possibly for accessing water and nutrients from a broader surface than the broadly compact forms as observed in *Microgramma owariensis, Pleopeltis macrocarpa,* and *Loxogramme lanceolata* (Tryon 1989). Succulent rhizomes were observed in *Davallia chaerophylloides* and *Drynaria laurentii* (outside sampled trees) and were restricted to the dry south part of the park.

Substrate Requirement Discussion

Most epiphyte species required the light humus substrate for germination and growth. The light humus provides water and nutrients necessary for germination and growth of epiphytic fern species (Tryon 1989). Few fern species were observed using the bark for germination.

Conclusion

A total of five families, twelve genera, and 24 species of epiphytic ferns were recorded in Kibale National Park. Families most heavily represented by species in Kibale National Park were Aspleniaceae and Polypodiaceae. Most of these species utilized the trunk regions of their hosts and rooted in a thin layer of humus. Those taxa relegated to the upper canopy exhibited greater succulence presumably related to drought tolerance. Selective logging did not influence the composition of the epiphytic ferns after 28 years of post logging.

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APPENDIX 1. Occurrence of epiphytic fern species on trees sampled in the logged (Kanyawara K14 and K15) and unlogged (Kanyawara K30, Ngogo and Kanyancu) forests by the Single Rope Technique (SRT) in Kibale National Park

Family	Species name and Author	Abbrevation	K-30	K-14	K-15	NGOGO	KANYANCU	Collection Nos.
Aspleniaceae	*Asplenium aethiopicum* (Burm.F) Becherer	Asp aet	+	+	+	−	+	MP/ 16, 75, 79
	Asplenium africanum Desv.	Asp afr	+	−	+	+	+	MP/ 4, 25, 111
	Asplenium anisophyllum Kunze	Asp ani	+	−	−	−	−	MP/ 110
	Asplenium geppi	Asp gep	+	+	+	+	+	
	Asplenium erectum Willd.	Asp ere	−	−	−	+	−	MP/ 1, 10, 157
	Asplenium gemmiferum Schrad.	Asp gem	−	+	+	−	−	MP/ 108, 140
	Asplenium 1	Asp 1	−	−	−	+	+	MP/ 139
	Asplenium megalura Hieron.ex Brause	Asp meg	+	+	+	−	+	MP/ 109, 144
	Asplenium sandersonii Hook.	Asp san	+	+	+	−	−	MP/ 78, 136
	Asplenium 2	Asp 2	−	−	−	+	−	MP/ 212
	Asplenium theciferum (Kunth.) Mett.	Asp the	+	+	+	+	+	MP/ 130
Polypodiaceae	*Lepisorus excavatus* (Bory ex Willd.) Moore	Lep exc	+	−	+	−	−	MP/ 158
	Loxogramme lanceolata (Sw.) C. Presl	Loxo la	+	+	+	+	+	MP/ 9, 132, 156
	Microgramma owariensis (Desv.) Alston	Micr ow	+	+	+	+	+	MP/ 13, 83, 138
	Platycerium elephantotis Schweinf.	Plat ele	+	+	+	+	+	MP/ 150
	Pleopeltis macrocarpa (Bory ex Willd.) Kaulf.	Pleo mac	+	+	+	+	+	MP/ 7, 8, 12, 112, 142
	Pyrrosia schimperiana (Mett. ex Kuhn) Alston	Pyr sch						MP/ 14, 72, 114, 137
	Microsorum punctatum (L.) Copel.	Micr Pun	+	+	+	+	+	MP/ 133
Oleandraceae	*Oleandra distenta* Kunze	Ole de	+	+	+	+	−	MP/ 17, 18, 19, 126
	Arthropteris monocarpa (Cordem.) C. Chr	Arth mon	+	+	+	+	+	MP/ 22, 24, 84
Vittariaceae	*Vittaria guineensis* Desv.	Vitt gui	+	+	+	−	−	MP/ 77, 113, 141
	Vittaria lividum	Vitt lin	−	−	−	+	−	MP/ 85
Davalliaceae	*Davallia chaerophylloides* (Poir.) Steudel	Dav cha	+	−	−	+	+	MP/ 43, 152
	Phymatosorus scolopendria (Burm. F.) Pichi Serm	Phy aco	−	−	−	−	+	MP/ 218