The flora of highly degraded and vulnerable wetland ecosystems of Nyamuriro and Doho, Uganda

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Abstract

The wetlands of Nyamuriro and Doho were surveyed for their flora during the period August 2001 and May 2002. These two wetlands are highly degraded through cultivation. The plants in these areas were documented with a view to determining their richness and conservation importance in Uganda. Two hundred and eight species were recorded in 140 genera, 63 families and 37 orders in Nyamuriro while 184 species, 109 genera, 39 families and 27 orders were recorded in Doho. Although there are no species of global priority conservation concern, these wetlands harbour reasonable numbers of plant species, some of them rare, for their size. Nyamuriro has five species of restricted range in the country occurring in only one of the four floristic regions. *Adenostemma caffrum* DC. var. *longifolium* Chiov., from Nyamuriro, is a new record for Uganda. Typically high-elevation species absent in most wetlands in Uganda, were recorded in Nyamuriro. Plants rare in Uganda were recorded from both Doho and Nyamuriro. These two wetland ecosystems are therefore still vital for the country's flora in terms of species richness, rarity and uniqueness. Nyamuriro needs urgent action to reverse the current trend of habitat loss and degradation. Doho was severely altered and there is a little chance for restoration.

Key words: biodiversity, conservation, degradation, ecosystem, flora, wetland

Introduction

Uganda has taken commendable strides towards the conservation and management of wetlands and rational utilization of their resources. Many of them are still at risk, and this situation might continue for some time to come (Humphries, Vane-Wright & Williams, 1991; Caldecott *et al.*, 1996). Tremendous pressure is exerted on these ecosystems arising principally from the need to find more land for cultivation of crops (NEMA, 2000, 2001; Harcourt & Parks, 2003; Xie, 2003; Miller *et al.*, 2004; Mishra *et al.*, 2004; Xu & Wilkes, 2004; Yip, Corlett & Dugeon, 2004). The wetlands of Nyamuriro in the southwestern, and Doho in the eastern region of the country, are a case in point of those facing a great risk (Byaruhanga, Kasoma & Pomeroy, 2001). These two wetlands have been subjected to tremendous levels of habitat degradation, endangering their ecosystem health and integrity, and threatening biodiversity (Krupnick & Kress, 2003). The Government Policy of 'Double Production' in the 1970s took a remarkable toll on the demise of many wetlands (UNEP, 1988).

Nyamuriro wetland, also identified as an important bird area (IBA), is under tremendous pressure due to shortage of land owing to high human population density in this area. It has been drained for growing crops. Specific threats to the conservation of biodiversity in Nyamuriro include: digging of canals; cutting of the plants including papyrus for fuel; heavy trampling by humans; pollution from the mining taking place nearby and whose wastes join and run through the wetland stream; burning of papyrus; grazing of livestock.

The population around Nyamuriro wetland is predominantly made up of subsistence cultivators at a density of 290 persons km^{-2} and an annual growth rate of about 2.17% (MFPED (Ministry OF Finance Planning and Economic Development), 2004). Over 80% of the local community survival is derived from the wetland through a number of ways including agricultural production, resources for housing, water, medicinal plants, papyrus for fuel and thatching, among others (*Nature*Uganda, 2004).

Originally a *Cyperus papyrus* L. swamp, Doho has now been grossly converted into an agricultural land for production of rice leaving only small patches with semi-natural vegetation. The few small patches are covered with

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Mimosa pigra L., *Eriosema glomeratum* Hook.f., *Echinochloa pyramidalis* Hitch. & Chase and *Aeschynomene*. The northern section of the IBA still has a thick, mature papyrus community (Kalema, 2005). Observable threats are conversion to cropland leaving far too little of the natural vegetation in the IBA. Many of the plants are weeds of cultivation.

Nyamuriro wetland is located at 29°43′E, 01°12′S in southwestern Uganda, covering 51 km^2 and its altitude ranges from 1922 to 2000 m. It is one of the few remaining sizeable high altitude wetlands in Uganda. The vegetation is predominantly *C. papyrus* swamp with stretches of *Miscanthus* mixed with *Typha* (Kalema, 2005). All the adjacent land is cultivated intensively and the gardens border the outer limit of the swamp. In this study, we surveyed the wetlands of Nyamuriro and Doho with a view to assessing their floral diversity and conservation significance. We describe the patterns of plant biodiversity in the two wetlands. There is no baseline data upon which patterns of vegetation change may be evaluated for these two wetlands. Accordingly, we make no attempt here to this end.

Materials and methods

Transects measuring 500–1000 m were established. The placement of these transects was not random but rather purposefully planned so that they followed some major environmental gradients characterizing each wetland. The transects were laid out to traverse a wide range of variations in distinct vegetation communities, moisture gradients and other environmental variables (gradsects). The sampling always started from the drier side towards the interior along a gradient of increasing water level. This judgemental strategy of placing the transects assumes that the greatest biological diversity in an area is associated with the maximum perceivable environmental gradients and therefore sampling along the steepest environmental gradient detects the maximum number of species in a given area (Wessels *et al.*, 1998). The transects were marked using a GARMIN 45 GPS navigator (Garmin USA, Inc., George Town, USA) by taking their universal traverse mercator kilometric coordinates.

Two 1 m radius circular plots were established, one on either side of the transect for sampling the plants. The plots were spaced at intervals of 10 m. A total of 292 plots were used in Doho while in Nyamuriro the number was 398. All the vascular plants within the plots were identified to species or subspecies level and recorded. The percentage cover of each species was estimated visually using the Domin scale (see Kent & Coker, 1992). The area of ground within a plot which was occupied by the parts above ground was estimated by looking at the species from above. Each species was then assigned a value ranging from 0% to 100%.

Considering that different species of plants have different phenological and life cycles, the sampling regime was such that repeat visits were made for each wetland so that each was visited once in the dry and once in the wet seasons of the year. This was intended to enable capturing of variation in floral assemblage due to seasonality. The available climatic data from the regions in which the IBAs are located were used to identify these seasons and the visiting was scheduled according to these climatic patterns.

More rapid inventory sampling and recording of plants were also carried out in as many different habitats in each IBA as possible in the time available. This was done with such a purpose of identifying special azonal habitats through deliberate visits to any special habitat or site that was expected to harbour plants that had not been encountered on the transects.

The computer programme *EstimateS* (Robert K. Colwell, University of Connecticut, CT, USA) Version 6.0b1 was used to do the analysis of species diversity and prediction of total species richness (Colwell, 1997) in combination with *Excel*. The distribution information was principally derived from the Flora of Tropical East Africa (FTEA, 1952 onwards), the Flora of West Tropical Africa (FWTA, 1968) and Hedren (1989). In some instances where a particular flora family was not yet published, the material available at the Makerere University Herbarium and Kew was looked at to obtain the distribution of the species at least in the flora area. Information about levels of global threat were obtained from the Red List of Plants on the IUCN website (http://www.iucn.org). The software package PC-ORD Version 4 (McCune & Mefford, 1999) was used to perform gradient analyses based on detrended correspondence analysis (McCune & Grace, 2002).

Results

Floristics and diversity

The total records in Doho were 184 species, 109 genera, 39 families and 27 orders. The most common orders were: Cyperales, Fabales, Asterales, Scrophulariales and Commelinales while the most common families included

Poaceae, Cyperaceae, Papilionaceae, Asteraceae and Commelinaceae (Table 1). The most common genera were *Cyperus*, *Leersia*, *Commelina*, *Ludwigia* and *Cayratia* and the species included *Leersia hexandra* Steud., *C. papyrus*, *Cayratia ibuensis*, *Acroceras zizanioides* (Kunth) Dandy, *M. pigra*, *Cyperus dives* Del. and *Cyperus latifolius* Poir.

The numbers of taxa recorded in Nyamuriro were 208 species, 140 genera, 63 families and 37 orders. The dominant orders in Nyamuriro were: Cyperales, Asterales, Polygonales, Apiales, Lamiales and the families included Cyperaceae, Asteraceae, Polygonaceae, Poaceae, Apiaceae and Lamiaceae (Table 1). The most dominant genera were: *Cyperus*, *Crassocephalum*, *Persicaria*, *Hydrocotyle*, *Carex* and *Miscanthus* while the dominant species were *C. papyrus*, *C. latifolius*, *Crassocephalum picridifolium*, *Hydrocotyle ranunculoides* L.f., *Carex cognate* Kunth var. *congolensis*, *Thelypteris confluens* (Thunb.) Morton and *Miscanthus violaceus* (K.Schum.) Pilg.

Limited range species

Nyamuriro registered five species of restricted range in the country occurring in only one of the four floristic regions. These were: *Acacia mearnsii* De Wild., *Hypolepis sparsisora* (Schrad.) Kuhn, *Galium simense*, *Peucedanum scottianum* Engl. and *Psydrax subcordata* (DC.) Bridson var. *subcordata*. There were also other species of distribution interest, thus: *Adenostemma caffrum* DC. var. *longifolium* Chiov., from Nyamuriro, was a new record of this variety for Uganda. The species is not new but the variety is *Alchemilla ellenbeckii* and *Alchemilla kiwuensis* are species that can only be found at high elevation. Consequently, only a high altitude wetland such as Nyamuriro can harbour it.

Andropogon eucomus Nees (previously known only from eastern and central Uganda) was recorded from Nyamuriro. *Carex cognata* var. *congolensis* the only variety of this species which occurs in Uganda, is described as being rare in the country though locally common in the Kigezi area (Haines & Lye, 1983) where our material was obtained. *Conyza clarenceana*, *Verbascum brevipedicellatum* (Engl.) Huber-Morath are high altitude species from Nyamuriro. *Cyperus renschii* Boeck. is uncommon in Uganda.

Cyperus rigidifolius Steud. was typically found in humid upland areas (Haines & Lye, 1983). *Galium aparinoides* Forssk. is an upland forest species. *Mentha aquatica* L., *Thalictrum rhynchocarpum* Dillon & A.Rich., *Trifolium purseglovei* J.B. Gillett, *V. brevipedicellatum*, *Plectranthus alpinus*, *Philippia benguelensis* Engl. are high altitude species. Doho also registered a few species of interest. *Cyperus dichrostachyus* A. Rich., *Cyperus digitatus* Roxb. ssp. *auricomus* (Spreng.) Kuk, are uncommon in Uganda (Haines & Lye, 1983) though widespread. *Cyperus imbricatus* Retz., *Cyperus melanospermus* (Nees) Valck. Sur. var. *hexalatus* (K. Lye) K. Lye, *Cyperus halpan* L., *Cyperus densicaespitosus* Mattf. (*Kyllinga pumila* Michx.) and *Cyperus renducus* are rare in Uganda (Haines & Lye, 1983).

Table 1 The most abundant taxa in the wetland ecosystems of Doho and Nyamuriro

Order	Proportion	Family	Proportion	Genus	Proportion	Species	Proportion
Doho							
Cyperales	0.3458	Poaceae	0.1795	Cyperus	0.1525	*Leersia hexandra*	0.0606
Fabales	0.1343	Cyperaceae	0.1663	Leersia	0.0606	*Cyperus papyrus*	0.0501
Asterales	0.0760	Papilionaceae	0.0920	Commelina	0.0468	*Cayratia ibuensis*	0.0391
Scrophulariales	0.0540	Asteraceae	0.0760	Ludwigia	0.0452	*Acroceras zizanioides*	0.0380
Commelinales	0.0468	Commelinaceae	0.0468	Cayratia	0.0391	*Mimosa pigra*	0.0380
Myrtales	0.0463	Onagraceae	0.0452	Mimosa	0.0385	*Cyperus dives*	0.0358
Polygonales	0.0396	Polygonaceae	0.0396	Acroceras	0.0380	*Cyperus latifolius*	0.0336
Nyamuriro							
Cyperales	0.3292	Cyperaceae	0.2567	Cyperus	0.1858	*C. papyrus*	0.0838
Asterales	0.1938	Asteraceae	0.1938	Crassocephalum	0.0982	*C. latifolius*	0.0538
Polygonales	0.0861	Polygonaceae	0.0860	Persicaria	0.0815	*Crassocephalum picridifolium*	0.0527
Apiales	0.0520	Poaceae	0.0724	Hydrocotyle	0.0478	*Hydrocotyle ranunculoides*	0.0444
Lamiales	0.0485	Apiaceae	0.0520	Carex	0.0417	*Carex cognata* var. *congolensis*	0.0417
Parkeriales	0.0368	Lamiaceae	0.0466	Miscanthus	0.0364	*Thelypteris confluens*	0.0375
Violales	0.0345	Dryopteridaceae	0.0349	Mikania	0.0356	*Miscanthus violaceus*	0.0364

Table 2 Species richness estimation and species diversity in Nyamuriro and Doho wetlands

IBA	Samples	Species on transects (T)	Species on transects and inventories (T + I)	Richness estimation	Diversity index
				Jackknife 2	Shannon
DHO	292	114	184	145.90	4.02
NYR	398	151	208	215.85	3.89

T, species recorded only during transect sampling; T + I, species recorded during both transect and inventory sampling.

Species diversity and estimation

Although Nyamuriro was more species rich, Doho, which was more heavily disturbed and degraded, had higher species diversity (Table 2). The predicted numbers of species in the two wetlands (using the Jackknife estimator) were 145.9 and 215.85 for Doho and Nyamuriro respectively. These are based on the performance of the sampling procedure on the transects. The level of closeness of transect species numbers to the estimated total species was slightly higher in Doho than in Nyamuriro (78% compared with 70% respectively) although the two were quite comparable. Nyamuriro thus had higher chances of registering more species with further sampling than Doho.

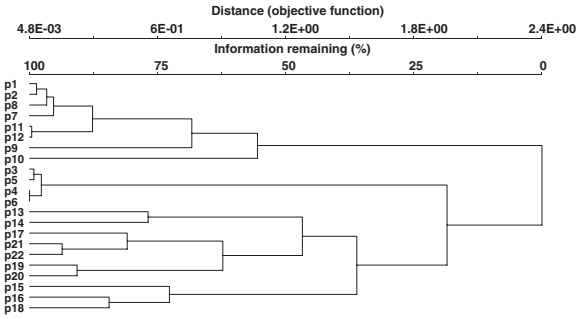

Fig 1 Dendrogram showing clustering of the samples in Nyamuriro

Phytosociology

The results of cluster analysis in Nyamuriro are shown in a dendrogram (Fig. 1) which shows that two main clusters may be distinguished, apparently representing two major communities, of which one may be subdivided. Figure 2 shows the species-samples ordination demonstrating the two groups of samples that represent the above mentioned two groups of vegetation community on the first two axes, 1 and 2. One community was slightly more diffuse than the other. Community 1 in the ordination diagrams represents the community composed mostly of *Miscanthus-Typha-C. papyrus* with medium level of disturbance due to cultivation and less of the weedy species. Community 2 was not quite distinct from community 1 but the former had more weeds of cultivation such as *Sonchus* sp., *Digitaria abyssinica* Stapf, *Lantana trifolia* L., *Crassocephalum* sp., *Emilia discifolia* (Oliv.) C. Jeffrey, etc. This group of samples was much more disturbed with cultivation creating several patches of cultivated land and fragmented pieces of natural vegetation.

The dendrogram in Fig. 3 shows the two main clusters in Doho that may be distinguished. Figure 4 shows the joint plot of species-samples ordination in which the same

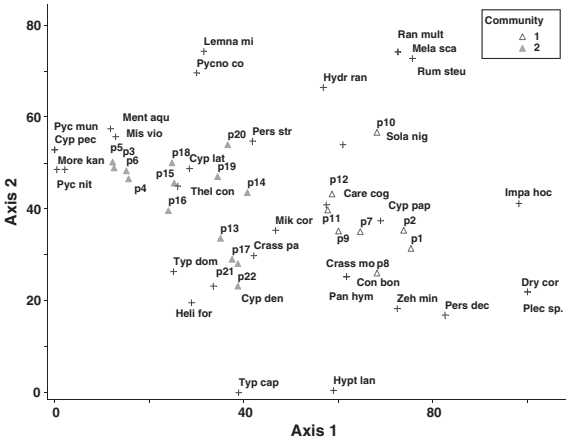

Fig 2 A two-dimensional species-sample ordination plot derived from detrended correspondence analysis (DCA) for Nyamuriro on axes 1 and 2

two groups of samples as in the dendrogram may be identified. Community 1 represents the vegetation samples in the patches that are more associated with the papyrus swamp composed of such species as *L. hexandra*, *Ipomoea rubens*, *Adenostemma* sp., *Typha* sp. Community 2 is basically representing the areas of former swamp that are now

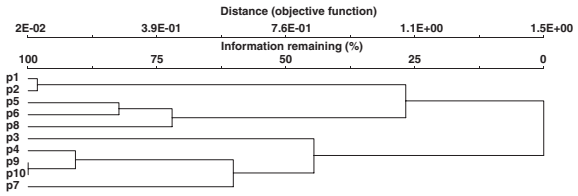

Fig 3 Dendrogram showing clustering of the samples in Doho

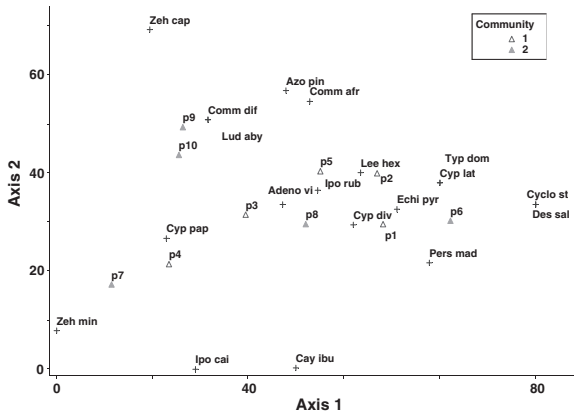

Fig 4 A two-dimensional species-sample ordination plot derived from detrended correspondence analysis (DCA) for Doho on axes 1 and 2

much disturbed by cultivation, which has resulted in the partial drying up of the vegetation and the introduction of such species as *Commelina* sp., *Ludwigia* etc. The two clusters are hardly distinguishable in the ordination diagram (Fig. 4) which shows the ordination of species across the samples.

Discussion

The results of floristics in the two wetlands ecosystems reflect the differential levels of disturbance. Thus Nyamuriro had more taxa although the two were of comparable size. However, Doho had higher species diversity. Although there are no species of global priority conservation concern, these wetlands harbour reasonable numbers of plant species, for their size, some of them rare in Uganda.

The two wetlands were both *C. papyrus* dominated swamps (Byaruhanga *et al.*, 2001) but became disturbed to different levels through cultivation (UNEP, 1988). Nyamuriro is still being disturbed through cultivation not being cleared completely (Ssegawa, 2003; Kalema, 2005). This introduced many species of weedy nature such as *Ageratum conyzoides*, *Conyza bonariensis*, *Crassocephalum vitellinum*, *Galinsoga parvifolia*, *Melinis repens*, etc. Doho, on the other hand, was even more heavily disturbed through cultivation and registered fewer species. This is essentially due to the level of disturbance which has left only small isolated patches of vegetation cover. Nonetheless, Doho's species diversity was high in the natural community patches. The heavier disturbance in Doho which has led to the introduction of several weeds of cultivation might have enhanced species diversity in Doho.

It is important to note that there were some new records from Doho i.e. *Nicandra physalodes* (Solanaceae), *Acmella uliginosa* (Asteraceae) and *Xanthium strumarium* (Asteraceae). But all these are weeds of cultivation and probably introduced. They are therefore not of conservation value as they may eventually become invasive and compete with the native flora (Hoddle, 2004; Homan *et al.*, 2004). Doho is a rice growing area with large fields under cultivation.

Nyamuriro clearly had more species of limited range distribution in the country owing to its high elevation. It accordingly had species that only occur at high altitude that were not registered in Doho. Some of these species are described as being rare in Uganda (Haines & Lye, 1983) and are therefore of much conservation interest. Whereas it is quite unlikely that rice growing will ever be reversed to allow restoration and recovery of Doho wetland, the encroachment of Nyamuriro can be stopped to avert further loss of habitat and its degradation. This, however, requires concerted effort by all stakeholders. There is remarkable dependence of the local communities on the wetland resources ranging from the use of papyrus for cooking fuel and thatching (*Nature*uganda, 2004) to the opening of the wetland for growing of crops (MFPED (Ministry OF Finance Planning and Economic Development, 2004). This dependence can be minimized through initiation of programmes that address the issues of land degradation in the catchment area (*Nature*uganda, 2004) where the communities reside. Through this route, the plant biodiversity, which includes a number of rare and other conservation concern species, will be protected.

Acknowledgements

The study was funded by the Danish International Development Agency (DANIDA) programme under its Enhancement for Research Capacity (ENRECA) project through Makerere University and University of Copenhagen collaboration. We are also grateful to the staff at the

Makerere University Herbarium (MHU), Royal Botanic Gardens, Kew, and the East African Herbarium (EA) for their help in identifying many of our plant specimens.

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Manuscript accepted 1 November 2006