

Conservation status of *Eulophia* species (orchidaceae) in Uganda, East Africa

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ABSTRACT

In order to propose conservation measures of *Eulophia* species, this study identified the location of the different species in Uganda in relation to the conservation status of the area. The major focus was on wetlands. Although Uganda's wetlands, a habitat for a variety of *Eulophia* are protected by the National Environment Statute (1995) most of them are still being reclaimed and degraded. The study shows that habitat alteration including total destruction, modification and fragmentation, are the main threats. *Eulophias* are also commonly appearing in horticultural industry. In 79% of the sites, less than fifty (50) individuals were recorded. These small numbers, together with occupying of restricted areas renders *Eulophia* species in Uganda vulnerable. The protected areas contain only 27% of total number of species (30) known to occur in Uganda. Unfortunately, the protected areas are becoming increasingly isolated islands of biodiversity which imposes serious limitations on genetic exchange. Suggestions on how conservation of *Eulophia* in wetlands of Uganda may be achieved are made with main focus proposed on *in-situ* conservation in addition to education and awareness of the communities.

INTRODUCTION

The unique morphological and anatomical adaptations, ecological complexity and popularity of the Orchidaceae inspires urgency for conservation considering the increasing pressure on their natural environment. Fortunately, *Eulophias* can be transplanted easily to damp situations in gardens (La Croix *et al.*, 1991). They have perennating organs such as tuberoids or pseudobulbs that enable them survive dry seasons. In this regard, *Eulophia* species are horticulturally attractive with much potential for hybridisation. Whereas the adventitious root system is tightly incorporated with an annual shoot in terrestrial orchids (Tatarenko & Kondo, 2003), periodic root growth is strongly correlated with shoot morphogenesis (Rasmussen & Whigham, 2002). This affects distribution, numbers and survival of the *Eulophias*.

Rasmussen & Whigham, 1998 report that great spatial and temporal variability in seedling establishment affects germination and survival of terrestrial orchids. Orchid populations as also reported for *Eulophia sinensis* (Sun, 1997) are often ephemeral because many species are colonizers but poor competitors (Sheviak, 1990), and change in land use patterns has been reported as a major threat (Tamm 1972 in Rasmussen and Whigham, 1998).

Dispersal limitations result in some degree of both genetic and demographic isolation among discrete populations. While migration allows for re-colonization of unoccupied habitat patches (Menges, 1991), the degree of isolation among populations is also important in determining the most appropriate geographic scale at which to pursue conservation efforts. Therefore the need to distinguish among alternative *Eulophia* population structures.

Studies have been done on *Eulophia alta* in South Florida in Johnson *et al.*, 2007 and 2009; Cribb, *et al.*, 2002 on *Eulophia epiphytica* in Madagascar; Sun and Wong, 2001 on *Eulophia sinensis*. The present status of knowledge on East Africa's orchids includes that of Summerhayes (1968) and Cribb (1984 and 1989). While Leakey (1968) listed the orchids of Uganda, the recognised species of *Eulophia* in Uganda are 30 (Cribb, 1989).

Physical alteration, habitat loss, habitat degradation, water withdrawal, over exploitation, pollution and the introduction of non-native species all contribute to declines in numbers and distribution of the *Eulophias*. Dhondt, 1996 reports that large scale habitat destruction places the remaining populations at risk because of demographic and environmental changes, habitat deterioration in the remaining fragments (Hamrick & Nason, 1996) and loss of genetic variation and inbreeding in small and isolated populations (Huenneke, 1991). The *Eulophias* are further exposed to unsuitable environmental conditions (mostly in marginal situations) and to predation, parasitism or competition.

For effective conservation, information on demographic factors affecting population persistence is required (Hutchings, 1991). No such monitoring programmes have yet been established for *Eulophia* in Uganda. Findings from this study could however be used to provide baseline information for initiation of the monitoring process.

Fortunately, all orchid species are protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Ramsar Convention also seeks to stem loss of wetland habitats, which beyond their value to waterfowl are home to many orchid species and especially *Eulophias*.

In Uganda, the horticulture industry is growing and *Eulophias* are among the plants being collected. The

increasing demand for ornamental plants at local level may also result in a severe load for some *Eulophia* species as these orchids are gathered from the wild including juveniles and species of no known commercial value. In addition, wetlands, a habitat to a variety of *Eulophias* are being altered. This inevitably results in decline in numbers of its species yet data on its distribution and conservation status is still limited. It is therefore essential that the opportunity is taken to conserve them.

Therefore, the objectives of this study were to:

- (i) Localize *Eulophia* in protected areas of Uganda,
- (ii) Establish the threats against *Eulophia* in wetlands in Uganda and
- (iii) Formulate conservation measures for *Eulophia* in Uganda.

METHODOLOGY

Study Districts and sites are located in Mbarara, Kisoro, Wakiso, Mukono, Mubende, Masaka, Nakasongola, Rakai and Masindi districts in Uganda, East Africa (Figure 1).

Reproductive status

The reproductive status of the *Eulophias* was determined by considering plants with single leaves, two or more leaves and plants with leaves and flowering stalks as individual plants. Data concerning *Eulophia* individual plants included species name, number of individuals

present, height, number of leaves, length of leaves, width of leaves and whether the plants are in vegetative state or are flowering or fruiting.

Location

Location of *Eulophia* was determined using the grid reference at the sites where it had been recorded before. Information from herbarium collections on actual location, in addition to that from the study sites was used to generate the map using a Global Positioning system (GIS) program.

RESULTS AND DISCUSSION

Eight *Eulophia* species were recorded in the wetlands. These are shown in table 1. Table 1 shows that the height, leaf width and length did not vary greatly for a particular species though at different locations, in most cases the plants were not in fruit, and the proportion of fertile to sterile individuals was small. Seed set was rare. Menges (1991) reports that in small populations ($N < 100$), genetic drift and inbreeding may cause a loss of genetic diversity. For the *Eulophias* studied (Table 1), 89% of the wetlands had < 50 individuals. There is therefore a cause for concern. Moreover insufficient flow of genes between and within populations due to fragmentation may affect *Eulophia*'s fitness to adapt to current and future environmental changes.

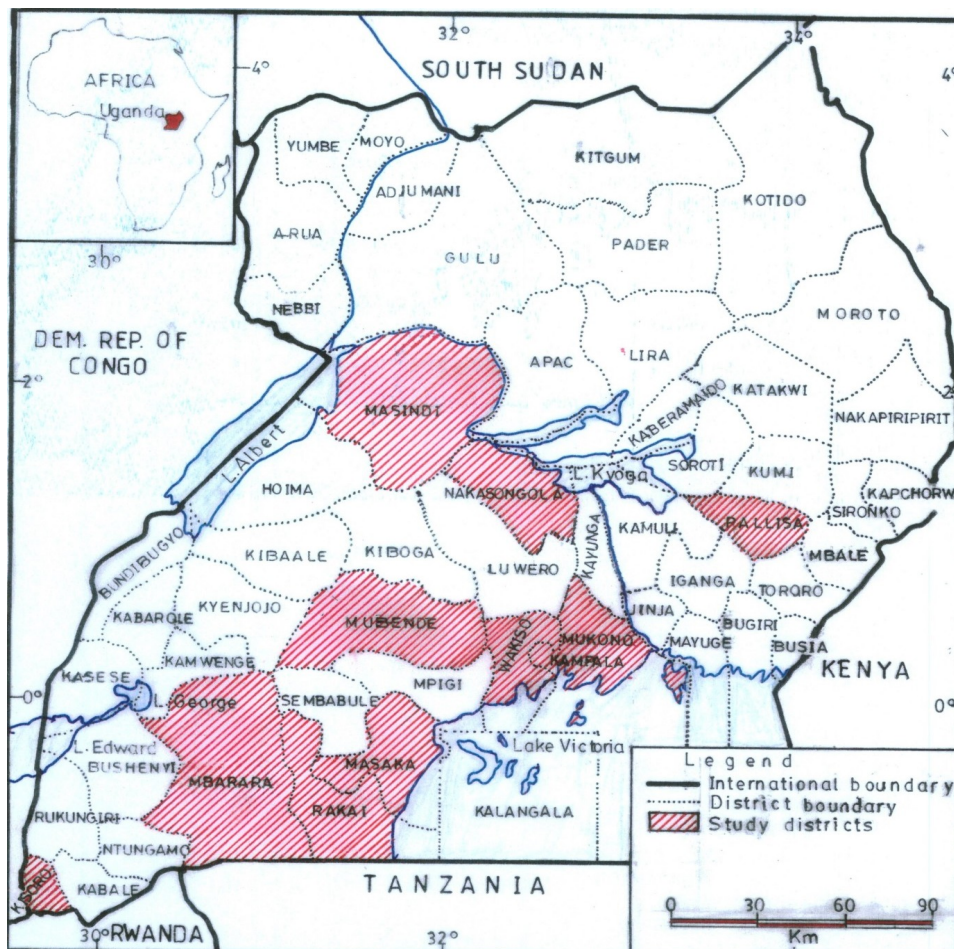


Figure 1. Location map of the study districts in Uganda.

Table 1. Morphological variations of *Eulophias* per wetland (averages used)

District	Site	Species	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)	Number of flowers	Number of fruits	Fertile: sterile stems	Petal colour
Kisoro	Mutanda	<i>E. streptopetala</i>	65.9	5.6	48.8	3.9	6.2	0	5:2	Pale yellow
Kisoro	Mutanda	<i>E. horsfallii</i>	91.9	2.8	58.8	6.1	0	0	0:9	-
Kisoro	Mulehe	<i>E. horsfallii</i>	122.6	4.2	49.5	7.3	38	0	4:80	Purple
Wakiso	Kajansi	<i>E. horsfallii</i>	152	4	118.6	4.6	35	0	1:4	Purple
Masaka	Nabugabo	<i>E. horsfallii</i>	132.1	4.8	76	5.1	3.4	0	3:4	Purple
Masaka	Nabajuzi	<i>E. horsfallii</i>	244	5	124	6.5	24	0	2:0	Purple
Mbarara	Ruizi	<i>E. horsfallii</i>	76.2	4.5	52.6	3.1	0	0	0:11	Purple
Masindi	Masindi	<i>E. horsfallii</i>	162.3	3.5	109.7	7.2	32	0	1.5	Purple
Wakiso	Kawanda	<i>E. latilabris</i>	120	4.6	78.5	11	1	15	9:43	Greenish purple
Mukono	Namanve	<i>E. latilabris</i>	107.3	3.5	66.2	7.1	28	0	0:4	-
Mukono	Sezibwa	<i>E. latilabris</i>	57.2	2.5	35.9	6.4	28	0	1:12	Greenish purple
Nakason-gola	Kasozi	<i>E. guineensis</i>	117.2	4.2	67.1	6.8	8	0	1:6	Light purple
Rakai	Mutukula	<i>E. clitellifera</i>	4.6	-	-	-	11	0	5:0	Pale yellow
Rakai	Mutukula	<i>E. subulata</i>	60.1	2	45.5	0.7	12	0	28:4	Pale yellow
Masaka	Degeya	<i>E. subulata</i>	25	2	33.3	1.1	12	0	2:1	Yellow
Masaka	Nabajuzi	<i>E. angolensis</i>	181.3	4	94.6	3.5	23	0	2:0	Yellow
Masaka	Njagalaka-sai	<i>E. angolensis</i>	112.6	4	68.8	3.6	8	0	2:1	Yellow
Rakai	Mutukula	<i>E. angolensis</i>	62	-	-	-	18	16	3:0	Yellow
Mubende	Myanzi	<i>E. angolensis</i>	98	5.5	81.4	3.5	42	0	2:4	Yellow
Masaka	Nabugabo	<i>E. speciosa</i>	74.3	7.5	55	5.7	10	0	1:3	Bright yellow

Table 2. Identified threats per species

Land use	<i>E. angolensis</i>	<i>E. clitellifera</i>	<i>E. guineensis</i>	<i>E. speciosa</i>	<i>E. horsfallii</i>	<i>E. latilabris</i>	<i>E. streptopetala</i>	<i>E. subulata</i>
Grazing	+	+	+	+	+	+	+	+
Industry	+	-	-	-	+	+	-	-
Brick making	-	-	-	+	+	-	-	-
Eucalyptus plantation	-	-	-	-	+	+	-	-
Trading centre	-	-	+	-	+	-	-	-
Cultural centre	-	-	-	-	+	+	-	-
Crop growing	+	-	-	-	+	+	+	-
Sugarcane plantation	+	+	-	-	+	-	-	+
Burning	+	+	-	+	+	+	+	+
Vegetation harvest	+	-	-	-	+	+	-	-
Fish ponds	-	-	-	-	+	-	-	-

(+ stands for observed; - stands for not observed)

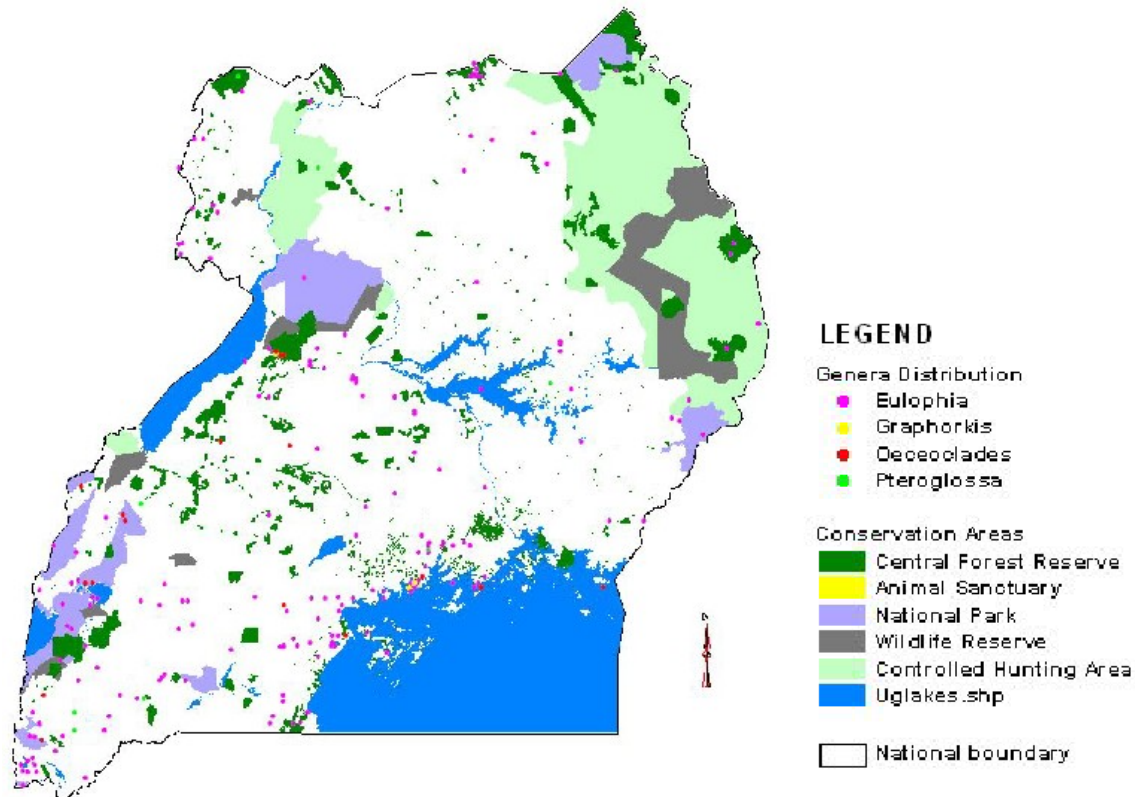


Figure 2. Distribution of *Eulophia* in Protected Areas

Figure 2 shows that *Eulophia* species are located in some protected areas. These are found in 100% of the National Parks, 1.4% (10/710) forest reserves, 7.7% (1/13) wildlife reserves and 80% of the major lakes in Uganda. The species found in these protected areas are *E.latifolius*, *E. milnei*, *E. speciosa*, *E. horsfallii*, *E. livingstoniana*, *E. zeyheri*, *E. subulata* and *E. streptopetala*. Within the protected areas, only 27% of the *Eulophia* species occur.

Uganda's human population is estimated to be rising at a rate of 3.4% per annum (Uganda Bureau of Statistics, 2002). This growth and the fact that over 80% of the population is agrarian are placing increasing strain on all natural resources. Human population growth has resulted in increasing need for land for agriculture hence encroachment on marginal lands for example the wetlands. The protected areas where *Eulophias* may be relatively safe are therefore becoming increasingly isolated habitats of biological diversity. This is expected to impose serious limitations on maintenance of *Eulophia* therein.

During the 2002 Protected Area rationalisation process, the future of Uganda's most important and viable protected areas was reaffirmed. It resulted in de-gazettement increasing the total area under strict wildlife protection from 20,349km² to 20,657km² (Roberts, 2003). Fortunately, some of the sites with *Eulophia* are designated as shown in Figure 2. These are; Bwindi Impenetrable National Park and Rwenzori Mountain National Park as World Heritage Sites; Lake George and associated wetlands and Kibale National Park as Ramsar Sites; and Queen Elizabeth National Park as a Man and Biosphere Reserve. However, 73% of the total number of *Eulophia* species occur outside these Protected Areas.

Although Uganda's wetlands are protected by the National Environment Statute (1995), most of them are still being reclaimed and degraded, especially those outside protected areas.

THREATS

Eight *Eulophia* species were encountered in varied wetlands during the study and threats associated with their habitats are given in table 2. *E. latilabris* and *E. horsfallii* in addition to being in protected areas were the only ones recorded in an area with some conservation options in place, a cultural centre. The major threats as shown in table 2 were:

a) Modification of the natural habitats

Habitat modification arises from many different types of land use change including agricultural development, logging, mining and development. All *Eulophia* species encountered face the risk of habitat alteration. Grazing and burning were common activities. They lead to loss of species that are not fire resistant and triggers succession changes leading to replacement of natural wetland vegetation. Road construction has an adverse effect on *Eulophia* populations not only because of alteration of the habitat but also because they often open the way to invasion of previously uninhabited areas.

b) Total destruction of the natural habitats

Loss and degradation of habitat is the most important factor that determines distribution of the *Eulophia* species. *E. horsfallii* and *E. speciosa* were most affected in this respect probably because they grow in soils that are preferred by the brick makers. *E. horsfallii* in permanently wet clay soils; and *E. speciosa*, close to termite

Table 3. Total wetland area (km²) and area converted by District, Uganda

District	Present coverage	Present area converted	Original coverage	Converted as % total original coverage	% District contribution to converted wetland area in Uganda	Wetland as % of total District area	Total area of District
Masindi	983	8	991	0.8	0.35	10.4	9,443
Nakasongola	2,422	28	2,445	1.1	1.17	26.3	9,204
Masaka/Rakai	1,425	12	1,436	0.8	0.5	20.3	7,010
Mukono	987	109	1,096	10.0	4.60	6.9	14,309
Wakiso/Mpigi	1,053	15	1,068	1.4	0.62	16.4	6,414
Kisoro	33	23	56	40.3	0.95	4.6	730
Mbarara	1,109	15	1,124	1.4	0.64	11.1	10,021
Mubende	758	25	783	3.2	1.05	12.2	6,198

Source: UBOS, 2002. (Only Districts of study included)

mounds. In Uganda, there is little or no control on the growth of cities and other human settlements. Excavation/mining may cause devastating direct effects on certain *Eulophia* habitats, at-least at the local level. This was mainly noted as a threat in Mukono District wetlands where large swampy habitats are being exploited for brickmaking and industrial development. This is likely to culminate in total loss of some species since the root systems are destroyed in the process.

c) Fragmentation of the habitats

Habitat fragmentation, noted as a threat to *Eulophia*, on one hand reduces population size by reducing the total habitat area; on the other hand, as reported in Wilcove et al., 1986, it affects dispersal and gene flow among the sub populations that remain separated. Fragmentation caused was mainly from construction of buildings, roads and agriculture. All species were affected in this respect.

Since species are under continuous selection pressure and man continues to interfere, a change in nature of the species is inevitable and this probably affects the distribution and number which generally was noted to be low at each site.

Table 3 shows that wetland conversion is rampant in Uganda with Districts like Kisoro, Mukono, and Mubende being most affected.

Illegal dumping of wastes mainly from industrial activities is another practice especially in wetlands close to town centres. This was noted in Mukono, Wakiso, and Masaka Districts. These wastes may completely change the chemistry of soils influencing the types of plants that can survive in such habitats.

The degree to which these threatening factors affect each *Eulophia* species varies according to geographical distribution, habitat specificity, and population size. As reported in Rabinowitz et al. 1986, these criteria provide a basis for estimating the relative rarity of orchids and other plant species.

CONSERVATION OPTIONS

Human activities usually have more drastic consequences for rare species, although even relatively common species may be threatened as a consequence of extensive habitat destruction and/or immoderate harvesting and collection. Exceptions may be those species found in inaccessible locations, areas that are unsuitable for human development, or effectively protected nature reserves. Such habitats are increasingly rare occurrences due to the ever increasing human population. Therefore, the need to start conservation moves need not be over emphasized. Proposed aspects to consider include:

Ecology of Eulophia

Conservation strategies for *Eulophia* species especially rare species should consider among other factors the rate at which new individuals are formed from the parent stock, the relationships of different individuals, their area of origin, and the size of their distribution areas. The populations of *Eulophia* encountered per site in this study were generally small (table I) and as reported in Sun & Wong, 2001, more population sites may need to be protected in order to maintain the total genetic diversity at the species level for their long - term survival.

Easy Propagation: Since members of the Genus *Eulophia* commonly grow from vegetative parts and are relatively easy to propagate, as a possible conservation measure, collection and storage of their seeds in a certified repository could be considered. The availability of seeds or even plants would be valuable should a need to reintroduce the species arise.

Further decline is likely with increasing human disturbance. Despite the pseudobulbs the *Eulophias* produce, the recruitment rate is low and they are restricted by their habitat requirement. Artificial transplanting of individuals in different populations may be advantageous to promote gene flow, since most populations are so isolated.

Effective Population size: The phenomenon of population size that could maintain typical amounts of heritable variation in selectively neutral quantitative characters could be sought. Franklin (cited in Lande, 1988) has proposed that a number of 500 (reproductive) individuals for any species can meet this requirement. It is worth noting that none of the sites surveyed had up to 500 individuals. Maximum number encountered was 84 individuals (Table 1).

In-situ conservation approach: With no information on local adaptation, *in-situ* conservation is preferred (Heywood, 1990; Frankel et al. 1995). In Uganda, there is no effort made yet in conserving target species by assessing their population status in the field, collecting germplasm for storage and propagation, developing appropriate propagation techniques and facilitating ex-situ conservation. Once done, this will lead to conservation of the habitats and the species.

Reserves establishment: Establishment of reserves is undoubtedly an important factor for maintenance of orchid diversity. It may be sufficient for the preservation of *Eulophia* species although many orchids are probably inflexible species because of their particular habitat preferences and complex symbiosis with other organisms.

Policy: The current status of *Eulophia* species in protected areas ought to be determined to ascertain the species that still exist there and whose chances of complete loss are minimised. However, not all Uganda's representative wildlife species and ecosystems are adequately protected. The conservation policies should not exclusively focus on protectionism. They should incorporate conservation education and awareness so as to fully interpret, understand and respect the implications, benefits, costs and consequences of conservation. The policies should propose a review of the protected area systems in the country to identify omissions. In particular wetlands should be targeted.

Monitoring program: In small populations as recorded for *Eulophia*, inbreeding can greatly reduce the average individual fitness, and loss of genetic variability from random genetic drift can diminish future adaptability to changing environments. It is important that a monitoring program occurs over a several year period to document the response of individuals and the populations over an extended period of time. However the effect of this treatment may not be immediately apparent and it is possible that a lag time of several years is necessary for an effect to be observed. The results presented in this paper form a baseline from which future changes can be monitored.

The immediate task would be to manage and conserve the existing natural resources in the wetland ecosystems but also the restoration of degraded ecosystems through co-operation and support of the local people.

CONCLUSION

Eulophia species though widely distributed in Central and Southern parts of Uganda, are sparsely distributed in the protected areas. Alteration of their habitats is the major

threat. In situ conservation is the preferred option and protected areas should be the first target.

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