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DIVERSITY AND DISTRIBUTION OF MACROPHYTES IN A FRESHWATER WETLAND, LOBOI SWAMP (RIFT VALLEY) KENYA

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ABSTRACT

An inventory of Loboi swamp was undertaken to determine the macrophyte diversity and distribution. A total of 36 vascular plant species in 13 families were recorded, with Cyperaceae forming over 30% of macrophytes. Two vegetation zones were observed, characterised by the presence of *Typha* and papyrus. The *Typha* zone, comprising over 70% of the swamp, is dominated by *T. domingensis* and is species rich with 35 plant species whereas the papyrus zone includes the dominant *Cyperus papyrus* and only one other macrophyte species. Distribution of macrophytes is correlated with depth and period under water, with the *Typha* zone seasonally flooded while the papyrus zone is permanently under water at depths over 0.5m. Water chemistry has little influence on the distribution of macrophytes in the swamp, but at the edges there is predominance of *Cyperus laevigatus* in high alkalinity soils. Current uses of the swamp include dry season grazing, harvesting of papyrus and other plant material for mat making and house thatching, and use of the swamp water for domestic and irrigation agriculture. Further monitoring is needed to evaluate the effect of the resource uses on the swamp.

INTRODUCTION

The lakes and wetlands of the East African Rift Valley are important to Kenya and the world. The valley is known as the "cradle of mankind" and preserves clues to the physical environment in which humans evolved. Many water bodies occur within the Rift Valley, but not all are potable. Water chemistry ranges from saline-alkaline (*e.g.* Lake Bogoria) to fresh (*e.g.* Lake Baringo) (figure 1; Hover *et al.*, unpublished data). These

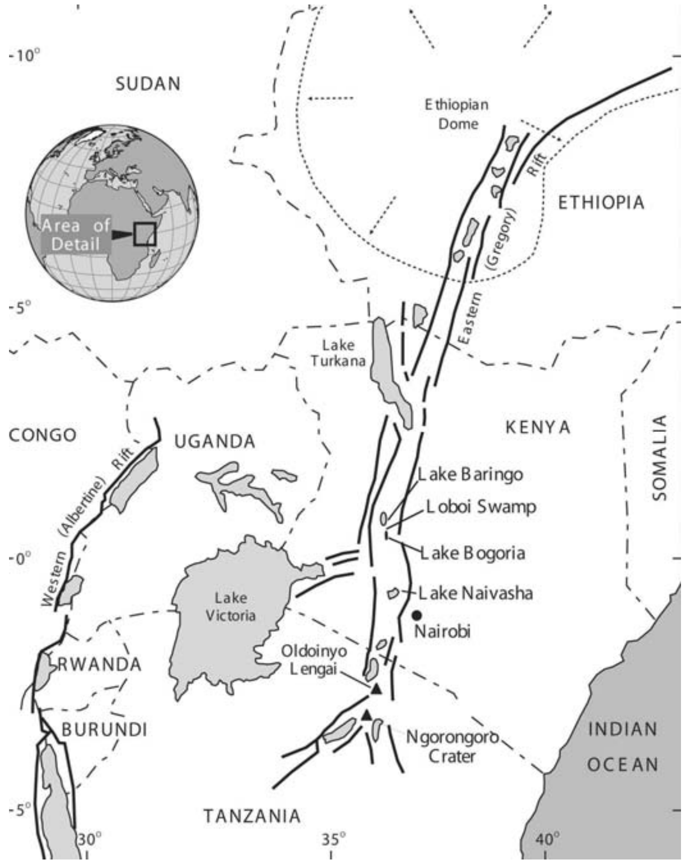

Figure 1. Regional map of East Africa showing the eastern (Gregory) Rift Valley and some of the major lakes and craters. The study area is located between Lake Bogoria and Lake Baringo, Kenya, just north of the equator.

lakes commonly have a unique biodiversity, such as endemic fish in Lake Baringo; and Lakes Baringo, Bogoria, Nakuru and Naivasha are protected under the Ramsar Convention as wetlands of international importance especially as waterfowl habitats (http://www.wetlands.org/RDB/ africa/Kenya_sites.html). While the sedimentology and geochemistry of the lakes have been studied extensively over the last few decades (Renaut *et al.*, 1986; Renaut, 1993; Renaut & Tiercelin, 1994), little attention has been given recently to the associated freshwater wetland environments. Lake Naivasha is an exception, and there has been concerted efforts to study the biodiversity, physical and chemical status of the lake and surrounding wetlands (Gaudet & Melack, 1981; Harper *et al.*, 1995; Gouder de Beauregard *et al.*, 1998; Everard *et al.*, 2002; Tarras-Wahlberg *et al.*, 2002). Specifically, little is known about the (1) water sources for the wetlands in these arid settings, (2) quality of water, or (3) expected longevity of the wetlands. As part of an interdisciplinary research program to better understand the ecology of wetlands in arid settings, a field based study of the diversity and distribution of macrophytes was undertaken in Loboi swamp (just north of Lake Bogoria) to inventory the vascular plant community, to determine a water budget for the swamp, and to assess water quality.

Loboi swamp, dating back to about 700 years before present, is an oasis in the dry and arid Lake Bogoria region in the Kenya Rift Valley (Ashley *et al.*, 2004). The swamp is among the limited and scattered sources of fresh water in the area where annual rainfall is erratic and averages 700 mm/year and the potential evaporation exceeds 2,500 mm/year (LaVigne & Ashley, 2001). Loboi swamp is recharged by at least two springs sourced in faults at the valley margin, several small ephemeral surface streams and the Loboi River (Ashley *et al.*, 2002). The swamp is used for both domestic and irrigation water for the surrounding communities, fodder for domestic animals and wildlife, and a source of thatching and mat-making materials.

METHODS

Data were collected in July and September 2002, coinciding with the wet and dry seasons, respectively. The area covered by the swamp was recognized by presence of the wetland macrophytes *Typha* (*Typha domingensis*) and papyrus (*Cyperus papyrus*), and mapped using a GPS (Global Positioning System). Distribution of macrophytes was studied along 15 representative line transects made from the edge of the swamp into the papyrus vegetation. Observations were made at sampling points at 20 m intervals, referenced with GPS readings, to include a record of all plants, the water depth and water samples taken for analyses of water quality parameters (pH, conductivity, alkalinity, ions). Field determinations of the plant species encountered were made using standard field guides for plants (Haines & Lye, 1983; Agnew & Agnew, 1994) with reference specimens collected using non-destructive sampling methods (Forman & Bridson, 1992). Voucher specimens have been deposited for long-term storage at the East African Herbarium (EA) and duplicate copies deposited at the Lake Bogoria National Reserve Headquarters.

RESULTS

The swamp, measuring about 3.5 km by 0.5 km and with total area 1.5 km^2, is deepest at the southern end with water about 2 meter deep and gradually becoming shallow towards the north away from the spring sources (figure 2). Two vegetation zones are observed in the swamp, defined by the distribution of *Typha* and papyrus. Areas covered by papyrus have permanent standing water over 0.5 m deep and macrophytes grow on a floating root mat, whereas areas occupied by *Typha* are only seasonally immersed.

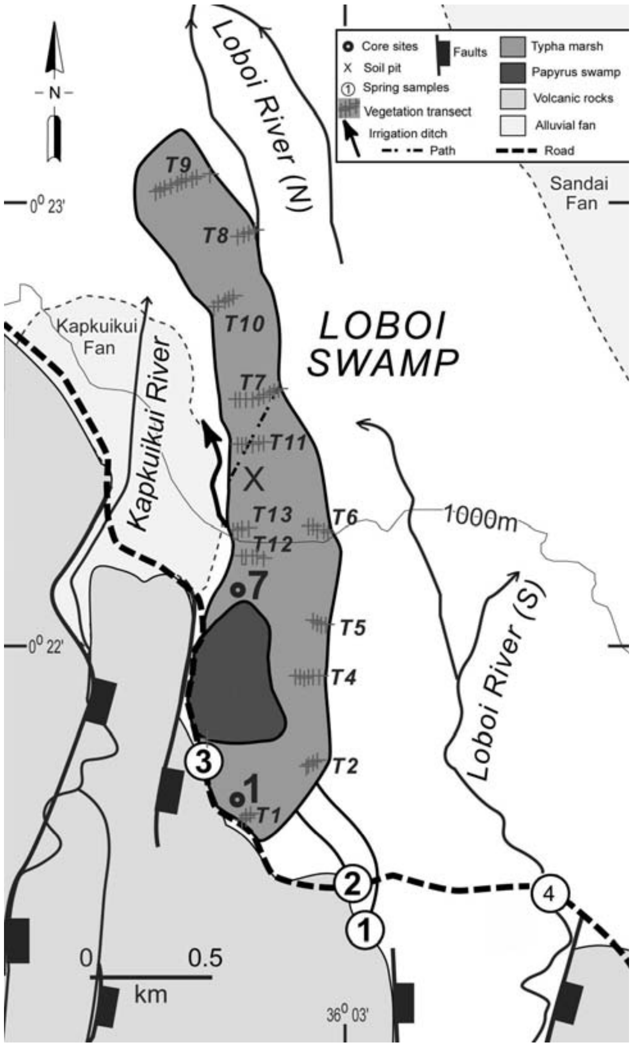

Figure 2. Map of Loboi Swamp showing macrophyte distribution and various sampling points.

A total of 36 vascular plant species in 13 families were recorded in the swamp (table 1). The *Typha* zone is the largest and contains the most species in Loboi swamp, with the exception of papyrus. *Typha domingensis* is almost always found growing together with *Leersia hexandra* and *Ipomoea aquatica*, and other species (table 1) scattered within. Restricted distribution was observed for *Cyperus laevigatus*, which is mostly localised at the southern margins of the swamp, and most in the interface between the *Typha* and wooded vegetation (figure 2; between spring sampling point 3 and T5). Two smaller patches dominated by *C. articulatus* and *C. latifolius* are observed on the eastern margin of the swamp (figure 2, around T4 and T5). The papyrus zone is nearly a pure stand of *C. papyrus* which forms floating mats on standing water, with scattered *Vigna luteola* vines climbing on the papyrus.

Table 1. Vascular plants recorded in Loboi swamp. Zone E refers to edge of swamp, T to Typha *and P to papyrus*

FAMILY	SPECIES	ZONE
AMARANTHACEAE	*Achyranthes aspera* L.	T
	Alternanthera pungens H.B.K.	T
ASTERACEAE	*Crassocephalum picridifolium* (DC.) S.Moore	T
	Pluchea bequaertii Robyns	T
	Pluchea ovalis DC.	T
COMMELINACEAE	*Commelina benghalensis* L.	T
	Commelina elgonenis Bullock	T
CONVOVULACEAE	*Ipomoea aquatica* Forsk.	T
CURCUBITACEAE	*Oreosyce africana* Hook.f.	T
	Zehneria scabra (L.f.) Sond.	T
CYPERACEAE	*Bolboschoenus maritimus* (L.) Palla	T
	Cyperus articulatus L.	T
	Cyperus laevigatus L.	T
	Cyperus latifolius Poir.	T
	Cyperus papyrus L.	P
	Cyperus rotundus L.	T
	Cyperus sp.	T
	Fimbristylis complanata (Retz.) Nees	T
	Fuirena pubescens (Poir.) Kunth	T
	Pycreus mundtii Nees	T
FABACEAE	*Acacia seyal* Del.	T/E
	Acacia tortilis (Forssk.) Hayne	T/E
	Senna didymobotrya (Fresen.) Irwin & Barneby	T
	Sesbania sesban (L.) Merr.	T
	Vigna luteola (Jacq.) Benth	T/P
LEMNACEAE	*Lemna perpusilla* Torrey	T/P
MALVACEAE	*Hibiscus cannabinus* L.	T
	Hibiscus diversifolius Jacq.	T
NYMPHAEACEAE	*Nymphaea nouchali* Burm.f.	?T
ONAGRACEAE	*Ludwigia leptocarpa* (Nutt.) Hara	T
POACEAE	*Cynodon dactylon* (L.) Pers.	T
	Echinochloa pyramidalis (Lam.) Hitchc.	T
	Leersia hexandra Sw.	T
	Panicum repentellum Napper	T
	Paspalidium germinatum (Forssk.) Stapf	T
TYPHACEAE	*Typha domingensis* Pers.	T

Water chemistry results from several sampling points are summarized in table 2. Various sampling points show small differences in the pH, conductivity and quantities of dissolved substances. An exception is the second sample (C. laevigatus, Brown Water), which has

Table 2. Loboi swamp water chemistry.

Sample Type	pH	Cond mS/cm	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Cl mg/l	NO3 mg/l	SO4 mg/l	Total Alk as HCO3 mg/l	Total Alk meq/l	GPS Lat (Deg Min)	GPS Lon (Deg Min)
Papyrus zone	7.16	0.635	7.333	1.97	136	17.5	9.70	0.90	9.70	383.1	6.279	N00 21.843	E036 02.687
C. laevigatus (Brown Water)	8.16	5.360	20.193	6.79	1290	136	5.30	0.50	7.30	3762.0	61.660	N00 21.608	E036 02.745
C. laevigatus / *Cynodon* (T4)	7.03	0.841	13.612	2.46	184	14.3	4.40	0.70	3.10	543.9	8.913	N00 21.936	E036 02.932
C. laevigatus (T5)	7.07	0.762	13.453	2.40	169	15.8	7.90	0.50	1.70	510.0	8.358	N00 22.050	E036 02.964
C. latifolius (T4)	6.87	0.630	8.626	1.51	131	15.4	8.20	1.00	5.10	398.1	6.525	N00 21.935	E036 02.916
Typha / *C. latifolius* (T5)	6.87	1.006	26.653	4.60	202	18.6	5.40	0.40	1.60	676.9	11.090	N00 22.058	E036 02.943
Typha zone	7.47	0.661	7.375	1.86	140	17.8	9.10	1.50	9.50	415.7	6.813	N00 21.625	E036 02.778
Irrigation Grove	7.21	0.640	7.397	1.67	150	16.9	8.30	0.20	4.00	409.7	6.714	N00 22.064	E036 02.727

higher values of sodium, potassium and carbonate ions, and consequently higher conductivity and more alkalinity. This sampling point has distinctly brownish water and is dominated by *C. laevigatus*. Other sampling points that contain *C. laevigatus* have water chemistry values more similar to habitats that support other macrophytes.

DISCUSSION

Topographic maps made in the 1970's show the swamp extending into the Loboi plain north of Lake Bogoria (Survey of Kenya, 1979). Field visits in 2002 established a 60% reduction in the size of the swamp to about 1.5 km^2 over the last 30 years. While the average rainfall recorded in Bogoria has remained nearly constant (LaVigne & Ashley, 2001), there has been an increased withdrawal of water from the swamp for irrigation purposes. The irrigation canal utilising the swamp water was dug in the early 1970s and it is evident that there is increased demand for water for cultivation. Vegetables and maize are now grown for local consumption and sale to outside markets. Since the recent El Niño rains (1997-98), Loboi River has changed course and is no longer flowing into the wetland.

Species diversity is high within the *Typha* zone but low in the papyrus zone. Over 30% of the macrophytes belong to the Cyperaceae, a family which is dominant in wetlands (Haines & Lye, 1983). Data from pollen analysis (Ashley *et al.*, 2004) show an increase in Cyperaceae pollen since the last 700 years, evidence which is supported by the current vegetation observations. Within the papyrus zone, the climax community dominated by floating *C. papyrus* is observed growing in near pure mono-stands. Similar observations of mono-stands of papyrus have been recorded in other wetlands in East Africa (Ssegawa, 2001). Loboi Swamp lacks submerged macrophytes, which are frequently observed in shallow open water in fresh water wetlands in Kenya (Harper *et al.*, 1995; Gouder de Beauregard *et al.*, 1998). This absence of submerged macrophytes can be attributed to the absence of open water in the papyrus zone.

The observed macrophyte distribution appears to be influenced by water availability. *Typha* and associated species (table 1) are rooted on ground that has fluctuating water levels (periodic submergence or drying), whereas papyrus forms floating mats. Presence of water throughout the year versus seasonal drying may be a major factor in determining the zonation and composition of the plants into papyrus and *Typha* zones in Loboi. In comparison, Lake Naivasha has little *Typha* and papyrus is found rooted at the lake edge in drying mud as well as floating above deeper water (Mavuti, pers. com.). In Ugandan wetlands, papyrus has been observed to grow in broad habitats as long as the habitat is sometimes flooded (Ssegawa *et al.*, 2004). The difference in distribution of the macrophytes between Loboi and Naivasha raises question as to whether other factors such as soil type are influencing the observed distribution patterns. In general, fluctuation in water level has been shown to be among the important factors influencing plant distribution in wetlands (Keddy & Fraser, 2000).

Water chemistry data from the papyrus and *Typha* zones is fairly similar. Most macrophytes grow in substrate that is slightly acid to basic, but only *C. laevigatus* is also observed in highly alkaline soils (table 2). *Cyperus laevigatus* is commonly growing at the edge of the swamp, in areas which have brownish water, or which have a brownish crust of top soil. Such brownish colour is perhaps due to the presence of carbonate and indicates high alkalinity conditions. *Cyperus laevigatus* and *Sporobolus spicatus* (Vahl) Kunth are recorded growing in high alkalinity soils at the shores of Lake Bogoria (Onkware, 2000).

No invasive alien macrophytes were recorded. Introduction of invasive macrophytes is increasingly an environmental concern in Kenya, with water hyacinth (*Eichhornia crassipes* (C.Martius) Solms-Laub.) dominating the shallow shore of Lake Victoria and recorded in several other fresh water bodies. *Prosopis juliflora* DC., an introduced legume shrub which is now invading semi-arid areas in Eastern Africa, was observed growing on dry soil on the edges of the swamp in 2002.

The local communities are using the Loboi swamp resources in various ways. The swamp is an important source of drinking water for people and their herds, and supports irrigation-fed agriculture. During the dry season, the *Typha* zone is nearly the only source of fodder for the cattle which graze on *Typha* and other plants in the swamp. The local women are organised into self-help groups to exploit papyrus stems for mat-making and *Typha* for house thatching, a venture likely to grow as more members join the group. As more members of the community exploit the swamp, there is danger of unsustained exploitation. Studies are needed to quantify the optimum levels of water use or harvesting of papyrus stems in a sustainable manner.

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