Journal of Wetlands Ecology
Wetland Friends of Nepal (WFN)
http://www.nepjol.info/index.php/jowe
ISSN: 2091-03632

Research Article

Plant Species Diversity and Composition of Two Wetlands in the Nairobi National Park, Kenya

W.K.S. RUTO[1], J.I. KINYAMARIO[1*], N.K. NG'ETICH[1], E. AKUNDA[1] and J.K. MWORIA[1]

[1]*School of Biological Sciences, University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya*

Published in November 2012

Abstract

Two wetlands (Hyena and Nalogomon) in the Nairobi National Park were investigated by comparing plant composition in and around their immediate vicinity. The most common aquatic plant species in the Hyena wetland was *Cyperus dives* while in the Nalogomon wetland was *Typha domingensis.* The terrestrial vegetation surrounding Hyena wetland dominated by while that of surrounding Nalogomon wetland was the grass *Hyparrhemia rufa*. It was also noted that Hyena Dam waters were colonized by aquatic weeds, namely *Gunnera perpensa*, *Enhydra fluctuans* and *Ludwigia abyssinica,* that were absent in Nalogomon wetland waters. This could have been due to eutrophication of the waters of Hyena Dam as it originated from human settlements (city estates) outside the park boundary.

Key words*:* Species Diversity, Wetlands, Aquatic Weeds, Nairobi National Park

[*]*Corresponding Author: J.I. Kinyamario; Email:* prof.kinyamario@yahoo.com*; Phone: +254-723072080*

INTRODUCTION

The Ramsar Convention defines wetlands as areas where water is the primary factor controlling the environment and the associated plant and animal life. Wetlands occur where the water table is at or near the surface of the land, or where the land is covered by water. Under the text of the Convention (Article 1.1), wetlands are defined as: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres". The Convention recognizes five major wetland types, namely, marine (coastal wetlands including coastal lagoons, rocky shores, and coral reefs); estuarine (including deltas, tidal marshes, and mangrove swamps); lacustrine (wetlands associated with lakes); riverine (wetlands along rivers and streams); and palustrine (meaning "marshy" - marshes, swamps and bogs). Such areas may also be covered partially or completely by shallow pools of water. They are generally distinguished from other water bodies based on their water table levels and on the types of plants that thrive within them. Specifically, wetlands are characterized as having a water table that stands at or near the land surface for a long enough period each year to support aquatic plants.

Wetlands differ in their soil, landscape, climate, water regime and chemistry, vegetation, and human disturbance. Generally, wetlands are classified into two general categories: marshes and swamps. Marshes are defined as wetlands frequently or continually inundated with water, characterized by emergent soft-stemmed vegetation adapted to saturated soil conditions. In Africa, swamps are dominated by herbaceous vegetation and are characterized by very wet soils during the dry season and standing water during rainy season (Howard-Williams and Gaudet, 1985).

Studies on wetland vegetation community structure and the role of environmental change are fundamental towards defining these ecosystems. Each wetland has its own unique species community structure that is subjected to changes (Harper et al., 1999; Ashley et al., 2002; Ssegawa et al., 2004). Although high diversity in plant species composition have been recorded in various swamps (Beadle, 1974; Owen, 1992; Grytnes et al., 2006; Rainbow, 2007; Janousek, 2009), many African swamps are characterized by a few tropical species of the genera *Phragmites*, *Typha*, and species of *Cyperus* (Gaudet, 1979; Muthuri et al., 1989; Harper et al., 1999; Van Mooy et al., 2006; Owino and Ryan, 2007).

The diversity of plant species within a plant community reflects the complexity in their physical, chemical and human environments (Sundt-Hansen et al., 2006; Whittaker, 2006; Moss, 2008). Gichuki et al. (2001) showed that there are strong relationships between environmental quality and vegetation composition and abundance with strong coupling effects being in those areas that are prone to anthropogenic disturbances in the catchment of a water body.

A number of authors (Tailing and Tailing, 1965; Tekeuchi, 2005; Abila et al., 2008; Stumm et al., 2009) have highlighted environmental change as the major driving force in regulating plant species composition in wetlands. Adaptations to changing environment with phases of fluctuating events can subject a plant community to dominance by the most competitive species. Van Mooy et al. (2006) have shown that species diversity of wetlands can be affected by environmental disturbances to a point where the habitat is dominated by a few species. Some studies (Allen et al., 2005; Abila et al., 2008) have shown that human factors have a very fundamental influence over plant species composition of wetland environments. Burns and Schallenberg (2001) observed that agriculture, fire and livestock grazing in wetlands may lower species diversity. Habitat influences such as clearing land for cultivation, construction of settlements or draining wetlands by man degrade the habitat and can cause local extinction of some species, thus reducing habitat species diversity (Primack, 1993).

Land use activities around wetlands in Nairobi National Park are dominated by wildlife grazing and human urban settlements. In the Nairobi National Park, wetlands are of vital ecological importance where they provide vital ecosystem goods and services to the biodiversity that inhabits the park. However, no previous ecological studies on these wetlands in the Nairobi National Park have been carried out.

The main objective of the study was to determine the environmental status of two wetlands in the Nairobi National Park, namely around Nalogomon and Hyena.

MATERIAL AND METHODS

Study Area

This study was conducted at two wetlands located around Nalogomon and Hyena dams, in Nairobi National Park, Kenya (Figure 1). Nairobi National Park is unique in that it shares a common boundary with the City of Nairobi. Hence a lot of human impacts from the city are increasingly being felt in the park. The boundary is fenced on the western and northern sides with electric wires to keep off wild animals from going into the city estates. However, water inflows from the city estates find their way into the park. The dams are located in the upper reaches of the park (1° 20' S and 36° 48' E) at distance of about 2.4 km from each other and are fed by separate water sources. The waters flowing into Nalogomon wetland originate from an upland forest while those flowing into Hyena wetland originate from urban settlements outside the park boundary. Animal species found in around the two dams include the Nile crocodile *(Crocodylus niloticus)*, hippopotamus *(Hippopotamus amphibious)*, various waterfowls, common warthog *(Phacochoerus africanus)* and various types of gazelles.

Data Collection and Analysis Methods

Plant species diversity within the wetlands was determined by laying two 100 m line transects across and on both side of each wetland, spanning each wetland into the dry terrestrial environment. Sampling was done in 1 x 1 m quadrats placed at 10 m intervals along the transects. All herbaceous species located in the quadrats were identified and their percentage ground cover estimated. These data were collected at the end of the rainy season before the start of the dry season at maximum plant growth (June 2011). The total count of each species (herbaceous and woody) along the transects at each wetland was used to calculate plant species diversity (the Shannon-Weiner index) using the standard equation (Kent and Coker, 1992; Ludwig and Reynold, 1988). Plant species were identified using taxonomic keys after Haines and Lye (1983), Ibrahim and Kabuye (1987), Agnew and Agnew (1994), and Beentje (1994). Plant species abundance and rank frequency were determined using PC-ORD version 5 (McCune and Mefford, 1997). All statistical analyses were done at probability level of $p \leq 0.5$ (Zar, 2001).

RESULTS AND DISCUSSION

The Hyena and Nalogomon wetlands had diverse plant species composition based on total number of species and the Shannon H' plant species diversity index (Table 1). Species diversity ordering in terms of species abundance showed that the number of rare or less common plant species at each site (based on alpha values < 2, Fig. 2 and Tables 2 and 3) were lowest at Hyena wetland (comprising *Setaria sphacelata, Enhydra fluctuans, Becium obovatum, Solanum incanum, Nesaea kilimandscharica, Dyschoriste radicans, Lantana camara, Sida tenuicarpa, Commelina benghalensis, Cyperus rigidifolius, Sphaeranthus suaveolens*, *Abutilon mauritianum* and *Cassia mimosoides*). Rare or less common species at each site were highest at Nalogomon wetland (comprising *Cyperus dives, Acacia gerandii, Scutia myrtina, Bothrochloa insculpta, Rhus natalensis, Orthosiphon sp, Rhynchosia minima, Becium obovatum, Aristida adoensis, Asystasia laticapsula, Ocimum kilimandscharicum, Aspilia mossambicensis, Setaria sphacelata, Stachys argillicola, Gomphocarpus fruticosus, Leucas nepetifolia, Vigna sp, Conyza sumatrensis, Cymbopogon caesius, Cynodon dactylon, Kalanchoe lanceolata*, *Solanum incanum, Tagetes minuta* and *Thunbergia alata*) (Fig. 2, and Tables 2 and 3). A total of 32 plant species were identified in Hyena wetland and 28 in Nalogomon wetland study sites respectively (Tables 2 and 3).

In addition, Table 1 and Fig. 2 show that Hyena wetland study site was the most diverse (Shannon H' = 2.259) in plant species compared to Nalogomon wetland study site (Shannon H' = 2.095). Likewise, the most common plant species numbers were highest in Hyena wetland and lowest in Nalogomon wetland (Fig. 2). The most frequent and dominant plant species at Hyena wetland study site were *Cyperus dives* in the wetland habitat proper while *Cynodon dactylon*, *Digitaria scalarum*, *Themeda triandra*, and *Heteropogon contortus* were dominant in the terrestrial habitats surrounding the dam (Table 2). At Nalogomon wetland study site, *Typha domingensis* was the most dominant in the wetland proper, while in the terrestrial habitats surrounding the dam, the most frequent species were *Hyparrhemia rufa, Ischaemum branchyatherum, Themeda triandra* and *Acacia gerandii* (Table 3). Hyena dam that receives its waters predominantly from human settlements (city estates) was found to be eutrophicated with higher levels of phosphates and nitrates (Ruto et al. *unpublished data*) in comparison to Nalogomon dam. Eutrophication can be defined as the gradual increase in the concentration of phosphorus, nitrogen and other plant nutrients in aquatic systems, which results in the system becoming more productive. Therefore, eutrophication may have caused the Hyena dam waters to be more productive through nutrient enrichment hence causing the waters to be colonized by aquatic weeds, namely Gunnera perpensa, *Enhydra fluctuans* and *Ludwigia abyssinica*. This phenomenon has been reported in other eutrophicated wetland water bodies in Africa (Marshall, 1993; Moyo, 1997; Chikwenhere and Phiri, 1999).

It was noted above that Hyena wetland site was more diverse (Shannon H' = 2.259) in form of species composition compared to Nalogomon wetland site (Shannon H' = 2.095). This could be due to habitat disturbance caused by the intense wildlife grazing (especially during the dry season as it forms a dry season grazing area for wildlife such as gazelles, zebras, buffaloes and warthogs) and impacts of human activities (city estates settlements) emanating from outside the park boundary through water inflows. No earlier studies have been carried in these two wetlands on species composition. However, the results obtained in our study are similar to those obtained in other Kenyan wetlands (Gichuki et al. 2001; Abila et al., 2008). Three important processes are thought to play a vital role in determining the ecosystem diversity of these two wetlands namely, competitive exclusion, disturbance and environmental heterogeneity (Connell, 1978). Competitive exclusion reduces species diversity as strong competitors first suppress lesser competitors and later drive them to local extinction. Disturbance, that may be in form of pollution, eutrophication or overgrazing, can reduce plant species diversity by eliminating disturbance-sensitive species; increase species diversity by opening up growing space and resources for use by colonizing species; maintain species richness by slowing or preventing competitive exclusion; and alter spatial heterogeneity in plant community composition. Ecological theory (Grime, 1973; Connell, 1978) also predicts important linkages between disturbance frequency and species diversity with more frequently disturbed ecosystems showing high species diversity through creation of microsites that are prone to colonisation by other species.

CONCLUSION AND RECOMMENDATIONS

The results of this study show that there were differences between the two wetlands in their plant species composition. These differences depended on the activities around the wetlands and the origin of the waters flowing into the two dam areas. It is postulated that due to nutrient loading from the nearby urban areas, Hyena Dam water is eutrophicated and therefore the proliferation of aquatic weeds noted in its waters. There is a need therefore to monitor levels of nutrient load and pollution levels that lead to proliferation of aquatic weeds in the wetlands of Nairobi National Park, a vital source of ecosystem goods and services to the faunal biodiversity found within the park.

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Annexes

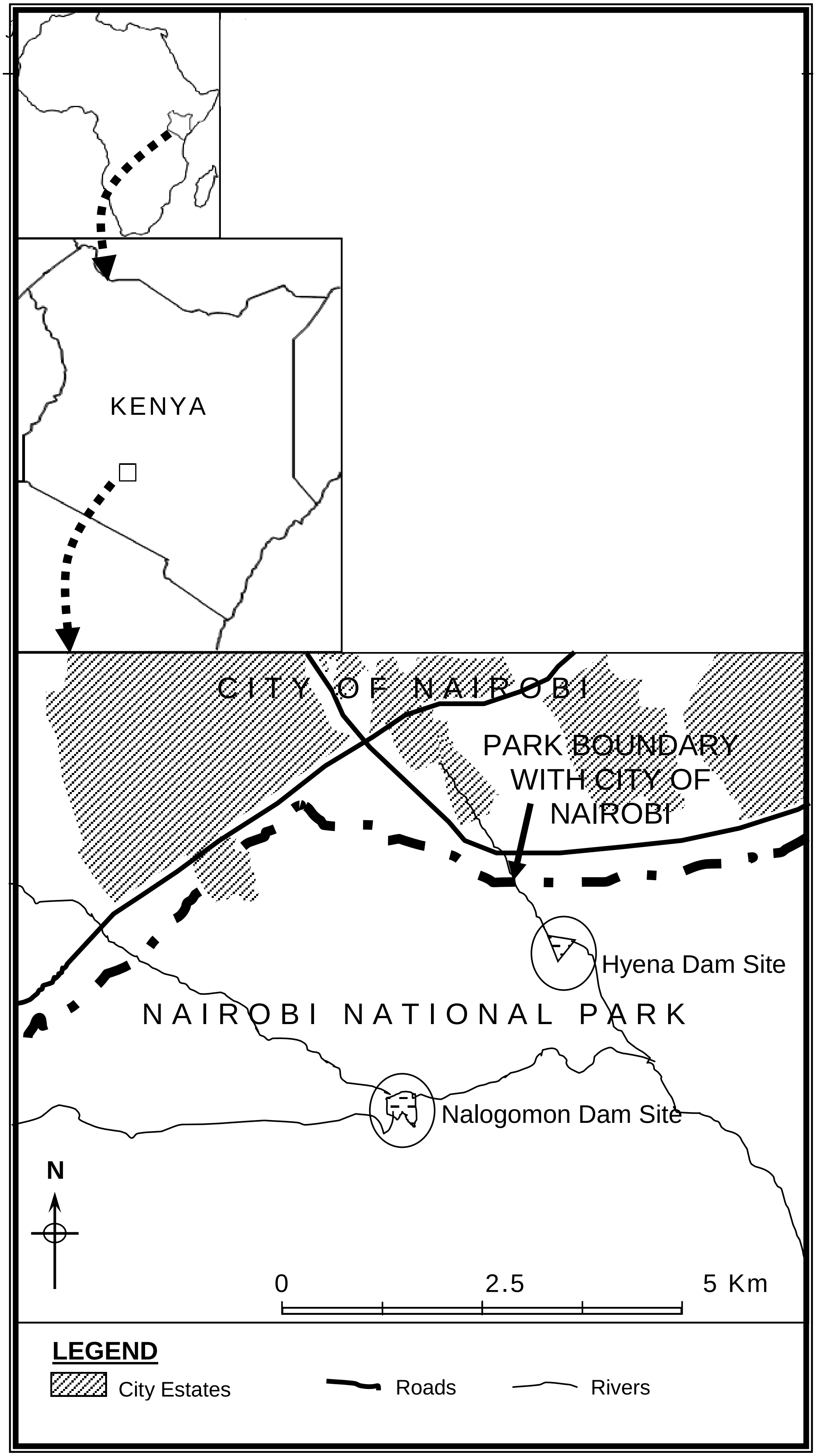

Fig. 1. Location of study sites.

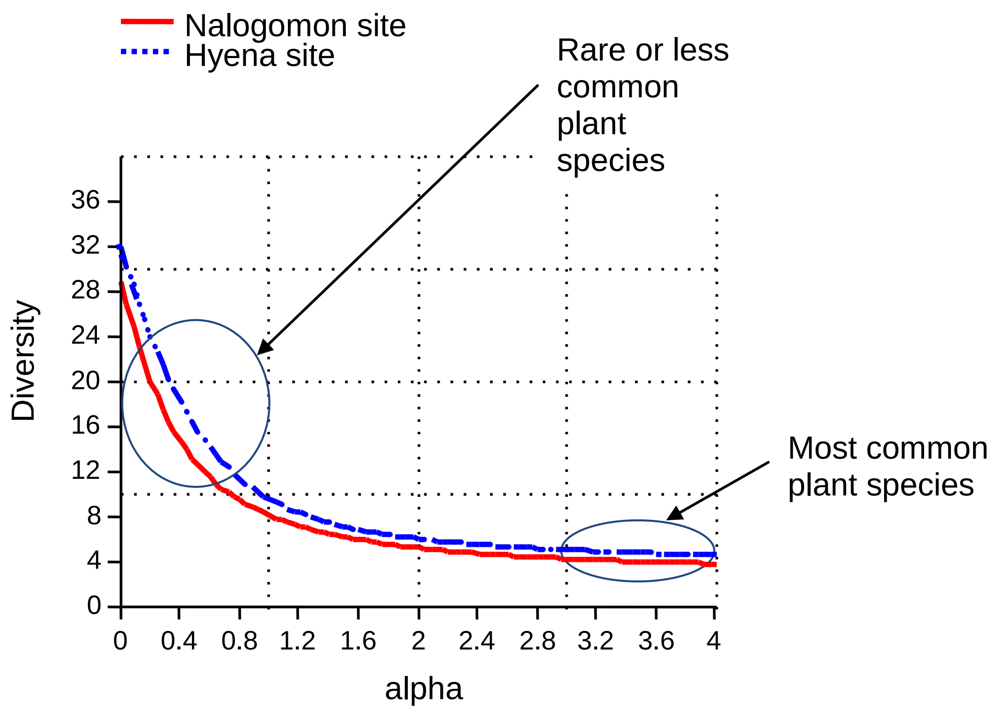

Figure 2: Diversity ordering in terms of species abundance of two wetlands; Nalogomon and Hyena study sites in the Nairobi National Park (Diversity alpha range 0 - 2 shows rare or less common species, 2 - 4 common species in terms of abundance). (Note: Hyena wetland has a higher profile than Nalogomon wetland, therefore the diversity ordering is Hyena > Nalogomon).

Table 1: Shannon H' plant species diversity index at the two wetlands

Value	**Nalogomon Wetland**	**Hyena wetland**
Species number	28	32
Shannon H'	2.095	2.259
Variance	0.00039205	0.00039519
t = -15.844		
df = 3841.2		

Table 2: Species list summary showing rank abundance and families of plants found in Hyena wetland in Nairobi National park.

Species Name	Family	Habitat	Rank Abundance	Log (Sum Abundance)
Cynodon dactylon	Poaceae	Terrestrial	1	3.08
Digitaria scalarum	Poaceae	Terrestrial	2	3.07
Themeda triandra	Poaceae	Terrestrial	3	3.07
Cyperus dives	Cyperaceae	Aquatic	4	2.78
Heteropogon contortus	Poaceae	Terrestrial	5	2.74
Typha domingensis	Typhaceae	Aquatic	6	2.56
Hyparrhenia rufa	Poaceae	Terrestrial	7	2.46
Aspilia mossambicensis	Asteraceae	Terrestrial	8	2.42
Chloris roxburghiana	Poaceae	Terrestrial	9	2.39
Eragrostis sp	Poaceae	Terrestrial	10	2.37
Orthosiphon sp	Lamiaceae	Terrestrial	11	2.32
Gunnera perpensa	Gunneraceae	Aquatic	12	2.29
Ludwigia abyssinica	Onagraceae	Aquatic	13	2.12
Pennisetum mezianum	Poaceae	Terrestrial	14	2.08
Ocimum kenyensis	Lamiaceae	Terrestrial	15	2.07
Rhynchosia minima	Leguminosae	Terrestrial	16	2.07
Indigofera arrecta	Leguminosae	Terrestrial	17	2.06
Asystasia laticapsula	Acanthaceae	Terrestrial	18	2.05
Achyranthes aspera	Amaranthaceae	Terrestrial	19	2.03
Setaria sphacelata	Poaceae	Terrestrial	20	2.00
Enhydra fluctuans	Amaranthaceae	Aquatic	21	1.94
Becium obovatum	Labiatae	Terrestrial	22	1.92
Solanum incanum	Solanaceae	Terrestrial	23	1.92
Nesaea kilimandscharica	Lythraceae	Terrestrial	24	1.91
Dyschoriste radicans	Acanthaceae	Terrestrial	25	1.91
Lantana camara	Verbenaceae	Terrestrial	26	1.90
Sida tenuicarpa	Malvaceae	Terrestrial	27	1.87
Commelina benghalensis	Commelinaceae	Terrestrial	28	1.85
Cyperus rigidifolius	Cyperaceae	Aquatic	29	1.83
Sphaeranthus suaveolens	Compositae	Terrestrial	30	1.83
Abutilon mauritianum	Malvaceae	Terrestrial	31	1.82
Cassia mimosoides	Leguminosae	Terrestrial	32	1.82

Table 3: Species list summary showing rank abundance and families of plants found at Nalogomon wetland in Nairobi National Park

Plant Species Name	Family	Habitat	Rank Abundance	Log (Sum Abundance)
Hyparrhemia rufa	Poaceae	Terrestrial	1	3.01
Ischaemum branchyatherum	Poaceae	Terrestrial	2	2.74
Typha domingensis	Typhaceae	Aquatic	3	2.30
Themeda triandra	Poaceae	Terrestrial	4	2.01
Cyperus dives	Cyperaceae	Aquatic	5	1.90
Acacia gerandii	Leguminosae	Terrestrial	6	1.87
Scutia myrtina	Rhamnaceae	Terrestrial	7	1.83
Bothrochloa insculpta	Poaceae	Terrestrial	8	1.81
Rhus natalensis	Anacardiaceae	Terrestrial	9	1.76
Orthosiphon sp	Lamiaceae	Terrestrial	10	1.76
Rhynchosia minima	Leguminosae	Terrestrial	11	1.72
Becium obovatum	Labiatae	Terrestrial	12	1.72
Aristida adoensis	Poaceae	Terrestrial	13	1.71
Asystasia laticapsula	Acanthaceae	Terrestrial	14	1.64
Ocimum kilimandscharicum	Lamiaceae	Terrestrial	15	1.63
Aspilia mossambicensis	Asteraceae	Terrestrial	16	1.62
Setaria sphacelata	Poaceae	Terrestrial	17	1.61
Stachys argillicola	Lamiaceae	Terrestrial	18	1.61
Gomphocarpus fruticosus	Asclepiadaceae	Terrestrial	19	1.58
Leucas nepetifolia	Lamiaceae	Terrestrial	20	1.48
Vigna sp	Fabaceae	Terrestrial	21	1.38
Conyza sumatrensis	Asteraceae	Terrestrial	22	1.34
Cymbopogon caesius	Poaceae	Terrestrial	23	1.34
Cynodon dactylon	Poaceae	Terrestrial	24	1.32
Kalanchoe lanceolata	Crassulaceae	Terrestrial	25	1.23
Solanum incanum	Solanaceae	Terrestrial	26	1.20
Tagetes minuta	Asteraceae	Terrestrial	27	0.85
Thunbergia alata	Acanthaceae	Terrestrial	28	0.78