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A Comparative Study of Plant Species Composition of Grasslands in Saiwa Swamp National Park and Kakamega Forest, Kenya

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ABSTRACT Kakamega forest is a tropical rain forest ecosystem while Saiwa Swamp National Park (SSNP) is a riverine ecosystem. A study was conducted to determine plant species diversity of the grasslands in both the ecosystems with emphasis on herbs and grass species, and the structure of the ecotones. The objective of study was to compare the plant species richness of these two ecosystems with an aim of proposing some conservation strategies. Species diversity was determined using inverse Simpson Index. The sampling sites were determined using stratified random sampling. The random quadrats (1x1M), line intercept, and nested quadrat sampling methods were used to collect data from the clear grassland. A 5x5M sampling plot was used to collect data from the bushed-grassland community of both ecosystems. All plants species present were identified and recorded. The density, frequency, foliage cover, importance value indices and relative values were calculated. Temperature and relative humidity were determined. Results clearly show that Kakamega forest grassland community had the highest species diversity of 0.9 and an abrupt ecotone compared to Saiwa National Park of species diversity of 0.8 and a blending ecotones These results confirmed that, there is great variation in species diversity in both ecosystems and discontinuity of ecotones due to influence of environmental conditions.

INTRODUCTION

Tropical forest ecosystems are important because they act as reservoirs of biodiversity, sources of timber, medicinal plants, and carbon sinks and play a critical role in watershed protection (Richards 1996). Over the past century, growing human populations have put increasing pressure on tropical forests, threatening to inflict irreversible damage to these ecosystems (Fashing et al. 2004). By the late 1980s and early 1990s, only 2% of Kenya remained covered by indigenous forests (Wass 1995), and 80% of this remaining forest cover occurred in agricultural areas with high human densities (Tsingalia 1988). Previous researchers are of opinion that this scenario has contributed to an ongoing conflict between the land uses needs of Kenya's increasing human population and efforts to conserve these forests (Tsingalia 1988; Wass 1995). A forest that epitomizes this conflict is the Kakamega Forest, Kenya's only remaining Guineo-Congolian rainforest (Cords and Tsingalia 1982; Kokwaro 1988; Tsingalia 1988; Lung and Schaab 2006). Kakamega Forest is one of the most important reservoirs of biodiversity in Kenya (Wass 1995), yet it is surrounded by a human population whose density exceeds 675 individuals/km^2 (Tsingalia 1988). Kakamega forest is managed by two bodies; The Kenya Wildlife Service that manages the northern parts and the Kenya Forest Service (KFS) that manages the southern part. Kakamega Forest reserve covers an area of about 240 sq. kilometers and it was established in 1933.

Kakamega forest is classified as a semi-montane, semi-deciduous tropical rainforest (Lind and Morrison 1974). The forest is rich in flora and fauna. It has more than 400 species of butterflies, 33 species of snakes, some of which are of western origin, for instance carbon wildest and rhinoceros- horn viper (*Bitis nasicornis)* and there are several varieties of bird species, for instance western black headed and seed-eater bird species. Kakamega forest stands on fertile soils of volcanic origin that have not yet been leached of their nutrients by the heavy tropical rains. Rainforest plants are however, known to have adaptations that conserve nutrients, most of which are tied up in living tissues (Musila et al. 2005). In the early 1900s, the Kakamega forest was quite expansive. Over the years, however, large sections have been cleared as a result of the ever increasing

human population (Tsingalia and Kassilly 2009). Before European colonization of Africa, indigenous people exploited forest resources as evidenced by the great decrease in forest extent in eastern Africa as the Iron Age spread from the northwest (Hamilton 1984).

The Kakamega forest is stratified into five main layers. First layer is emergent layer which comprises of emergent trees. Second is the tree layer which comprises of three canopy layers; upper canopy (above 33m) which comprises of emergent trees. Such emergents include *Olea capensis, Antiaris toxicaria* and *Maesopsis eminii.* The middle canopy layer is the second tree layer and comprises of trees and woody climbers. Its height varies between 18 and 27m. Tree species found here include *Teclea nobilis, Albizia gummifera, Ficus exasperate*. The lower canopy layer is the third tree layer and comprises of small trees with height 14-17m and includes *Euclea divinorum, Syzigium sp, Chaetacum anistada, Afrommumium* sp. The shrub layer (10 – 13m) comprises of trees saplings and shrubs that include *Rhus* spp, *Maesa lancedata, Clarodendrum* spp. The herb layer is composed of tree seedlings, gramminoids, ferns, bryophytes and forbs. The ground layer is devoid of grass and comprises of bryophytes. Kakamega forest has an explicit abrupt ecotone due to abrupt discontinuity in environmental conditions as shown by different transitions between a grassland and forest interface. There was a sharp transition between grassland community and forest community and Kakamega forest grassland did not show physiognomic characteristics similar to those of African savannas (Brourlerie 1982; Tsingalia and Kassilly 2009).

Saiwa Swamp National Park was established in 1974 to protect a small population of semi-aquatic Sitatunga antelope *Tragelaphalus spekei* (Kavishe 2001). It is a riverine ecosystem made up of the main swamp surrounded by a riverine forest. There are patches of open and bushed-grassland communities. The park management believes that changes in the vegetation composition could alter the habitat and lead to a reduction in the population of Sitatunga in the park as reported by Kavishe (2001). The forest community that surrounds the swamp vegetation is restricted to the steep slopes that border the swamp. This is a unique habitat with endemic plant and animal species (Kavishe 2001). Common plant species include *Albizia gumnifera, Croton macrostachyus* and *Prunus africana* (Ogutu 1996). The fauna include sitatunga (*Tragelaphus spekei)*, bushbuck (*T. scriptus)*, reedbuck (*Redunca redunca)*, waterbuck (*Kobus ellipsiprymnus)*, De Brazzas monkey (*Cercopiyhecus neglectus* (of which 28 out of 100–200 Kenya population live in this park), the nocturnal potto (*Perodictus potto*) and blue monkeys (*Cercopitherus mitis*). The swamp vegetation consists of large stands of bulrush (*Typha domingensis*), reeds (*Cyperus latifolia*) and of the species richness in each different ecosystem is critical for planning strategy for long term conservation and provision of sustainable ecosystem services to the surrounding communities. The government and NGOs are already pursuing conservation measures in both Saiwa National Park and Kakamega forest, albeit from different approaches. It is this realization that motivated the current research. This research sought to compare the plant species richness of both Kakamega forest and Saiwa Swamp National Park, grasslands and to determine how the differences in climatic conditions and different government conservation policies and strategies have an impact on species differences.

Description of the Study Sites

Saiwa Swamp National Park is situated in Sinyerere location of the Trans-Nzoia District, 25 km north-east of Kitale town (01^0 00'N, 35^0 00'E), 375 km, due north west of Nairobi. The park which covers an area of 2.9 km^2 is situated at the confluence of rivers of Saiwa, which originates from the Cherengani ranges (3371 metres above sea level) to the north, and Kipsaina which originates from Mt. Elgon (4321 m) to the west. The two rivers join to form river Sinyerere that flows into river Nzoia further downstream (Kavishe 2001). Climatically, it is located in ecological zone 3 and receives medium amount of rainfall 1000mm – 1250mm that is weakly bimodal and falls between March and October with peaks in April and August. Between November and February it experiences dry seasons, with recorded annual mean temperature being 18.9^0C with a mean minimum of 12^0C and a mean maximum of 25.8^oC. Saiwa swamp is underlaid by acid to intermediate rocks of the Precambrian basement system covered by a layer of tertiary sediments resulting

from volcanic activity of Mt. Elgon (Kavishe 2001). Sediments and sand resulting from eruptions of the Cherengani ranges led to the creation of a hard crust. As a result the crust forms a high water table at 2.7m below the surface.

Kakamega forest on the other hand covers a total area of 240 km^2 and holds about 450 species of trees, most of them indigenous. At an average altitude of about 1580m above sea level, Kakamega forest receives more than 2000mm of rainfall per year. The mean diurnal temperature varies between 26-27^oC while at night it is 13^oC.

METHODOLOGY

The following values were calculated according to Githae et al. (2007) for every grass and shrub encountered: (i) relative frequency (RF), which is the number of plots in which a species occurred divided by the total number of occurrences of all species in plots; (ii) relative density (Rd), which is the number of individuals of a species divided by the total number of individuals of all species; (iii) relative dominance (RD), which is the basal area of a species divided by the sum of basal areas of all species. The importance value index (IVI) was then calculated by the summation of RF + RF + RD. Species diversity was calculated using the Simpson's Diversity index $=\lambda = \Sigma(ni/N)$. The random quadrat (1mx1m) and line intercept methods were used to collect data from grasslands. Five random quadrats were established within each sample area. All plants species present were identified and recorded. Densities, frequency, foliage cover (%), cover of grass within the quadrats was calculated. Importance value index from two parameters using relative cover, density and frequency was also calculated. Temperature and relative humidity was determined using wet and dry bulb thermometer in the afternoon. A 100m long line transect was laid and individual plants intercepting the line were identified recorded and their intercept widths measured and recorded. This data was used to calculate linear density, cover, frequency, as well as their relative values like relative cover, relative density and relative frequency were calculated. A sampling plot, 5Mx5M was set up for the bushed-grassland of Saiwa swamp National Park. The nested and random quadrat sampling methods were used to collect data from the bushed-grassland. All plant species were identified and recorded. The environmental parameters: temperature, relative humidity were determined.

RESULTS

Kakamega forest is rich in complex ecosystem, rich in flora which is a characteristic of a tropical rain forest. Apart from grass species, most of which are indigenous species, shrubs, grammminoids and forest possesses them all (Table 1a). In Kakamega forest, plant species richness increased with quadrat sampling (frequency per sample area) and this was very closely related to outcome of Saiwa Swamp National park (Fig. 1), probably an indication that species richness did not vary significant between the two ecosystems.

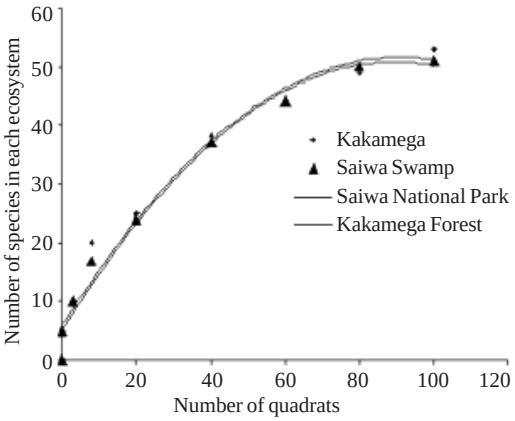

Fig. 1. The relationship between the number of quadrats thrown per sample area and number of plant species in both Kakamega forest and Saiwa National Park grasslands.

Kakamega grassland plant community had the highest species diversity of 0.9 as shown in Table 2 whereas Saiwa Swamp National park bushed-grassland community had (H)' 0.8 on average (Table 3). This shows that high species diversity in Kakamega forest was brought about by habitat structure, physical environments, climatic conditions, competition and nutrients that favored plant growth hence high species diversity. Kakamega forest grassland community displayed an abrupt ecotone because its species diversity was high. Transition from Kakamega forest community to grassland community is very sharp due to environmental

Table 1a: Kakamega forest grassland community species sampled (Total area sampled = 400m^2)

Species names	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*	*C*	*RC*	*D*	*RD*	*F*	*RF*	*Q*
Hyperenia roofer	9	20	10	6	1	0.17	0.21	9.2	0.37	100	23.53	46
Hyperenia pendipula	5	1	20	8	20	0.18	0.23	10.8	0.43	100	23.53	54
Crassophalum sp	-	1	-	-	-	0.04	0.05	0.01	0.01	25	5.88	1
Laggera breupes	-	1	-		-	0.06	0.08	0.01	0.01	25	5.88	1
Anjiuga remota		1	1		-	0.04	0.05	0.01	0.01	25	5.88	2
Commelina africana	1	-	1	1	-	0.09	0.05	0.02	0.02	25	5.88	3
Memosa pundica	-	-	1		-	0.01	0.11	0.01	0.01	25	5.88	1
Hyperinica henta	-	-	1		-	0.01	0.01	0.01	0.01	25	5.88	1
Solanum spp	-	-		1	-	0.04	0.01	0.01	0.01	25	5.88	1
Hyperenia spp	2	3		3	4	0.07	0.05	0.01	0.1	25	5.88	12
Leonatis spp	2	-		1	2	0.09	0.11	0.04	0.04	25	5.88	5
Total	14	24	54	14	21		1		1.02		100	

Important value index = RD+RC+RF where RD: Relative Density; RC: Relative Cover; RF: Relative Friquency.
Simpson's Diversity index = 102+100+100 D=1-D or 1-λ
= 302% or 3 $\lambda = \Sigma(ni)^2$
N
Dominant grass species: *Hyperenia* species D=0.3
D=1-0.09
$H^I = 0.9$

condition. *Aspilia* spp, *Hyperenia roofer, Commelina africana, Solanum* spp and *Anjiuga remota* species were dominant in the Kakamega grassland community and *Ficus* spp (Table 1b) which had covered almost 75% of the studied area. The Kakamega forest grassland community is rich in species diversity compared to Saiwa swamp bushed-grassland community. The Simpson index value for species diversity is 0.8 with low dominance index value of 0.2.

The vegetation of Saiwa Swamp National Park is also complex and covers a small area of 2.9 sq. kilometers. The bushed-grassland was made of scattered bushes, with a herbaceous layer of medium perennial grasses mixed with

Table 1b. Differences in relative humidity inside and outside Kakamega forest

	Outside of the forest	*Inside of the forest*
Temp	Hotter	Cooler
RH	Low	High

Temperature = dry bulb thermometer = 26^{0}c
Wet bulb thermometer = 25.5^{0}c
Relative humidity = 0.50^{0}c

forbs. *Hyperenia roofer, Hyperenia pendipula, Leonitis spp, and other Hyperenia* species (Table 3) were dominant plant species in the forest grassland species. *Albizia gummifera* occurred in the riverine, *Phoenix reclinata*_occurred in clumps on the edge of the swamp. Climbers and lianas, *Periploca linearfolia, Toddalia assiatica,*

Table 2: Kakamega forest grassland community species sampled by Line Intercept Methods D=100metre

Plant species	*L1*	*L2*	*L3*	*L4*	*L5*	*C*	*RC*	*D*	*RD*	*F*	*RF*	*Q*
Hyperenia roofer	1	3	4	2	6	1.85	16.36	0.16	21.33	100	14.7	16
Bidens pilosa	1	-	2	-	1	1.15	10.17	0.04	5.33	60	8.82	4
Aspilia spp	-	2	5	-	-	0.95	804	0.07	9.33	40	5.88	7
Leonatis spp	2	1	-	1	-	0.87	7.69	0.04	5.3	60	8.82	4
Commelina africana	1	4	3	-	-	1.05	9.28	0.07	10.67	60	8.22	8
Mimosa pundica	-	-	4	-	2	0.65	5.75	0.06	8	60	8.22	6
Solanums spp	-	3	1	-	3	0.96	8.49	0.07	9.33	60	8.22	7
Anjiuga remota	2	4	-	1	-	0.86	7.6	0.7	9.33	60	8.22	7
Crassophalum spp	3	1	-	1	-	1.12	9.9	0.06	8	80	11.76	6
laggera brevipes	-	2	1	1	1	1.02	9.02	0.04	5.33	60	8.82	4
Hyperenia pendipula	2	-	-	-	4	0.83	7.34	0.06	8	40	5.88	6
						ΣC = 11.31	ΣRC = 1100%		99.98		99.96	Σ Q 75

Key for indication: Source (Bodgan AV 1957; Beentje HJ 1994)
RC- Relative cover RD: Relative density and RF: Relative frequency
Important Value Index = RD + RF +RC= 99.98 +99.98 +100 = 300% or 3.
Simpson's Diversity Index: (Use inverse Simpson's Index)
D: 1 - λ Where $\lambda = \Sigma(ni/N)^2 = 0.9$
H'=0.9

Table 3: Saiwa Swamp National park bushed-grassland plant species: Total area sampled=25m^2

Plant species	*Q*	*GF*	*D*	*RD*	*C*	*RC*
Africana prunus	20	T	0.8	1.75	0.024	7.39
Maesa lanceolate	5	SH	0.2	0.44	0.003	0.92
Acacia hockii	16	SH	0.64	1.4	0.026	8
Maytenus heterophylla	18	SH	0.72	1.57	0.003	0.92
peripolca liuearfolia	23	C	0.92	2.01	0.002	0.62
Eriosema turioniarum	11	SH	0.44	0.96	0.027	8.31
Helichysum panduratum	105	F	4.2	9.18	0.026	8
Spermacole prissila	116	F	0.64	10.14	0.028	8.62
Kalanchoe densiflora	96	F	3.84	8.4	0.019	5.85
Rhus natalensis	24	SH	0.96	2.1	0.022	6.77
Melinus minutiflora	30	G	1.44	3.15	0.032	9.85
Leonatis spp	48	H	1.92	4.2	0.028	8.62
Berkeya spekeana	5	F	0.2	0.44	0.006	1.85
Setaria fasilata	21	H	0.84	0.84	0.014	4.31
Toddalia asiatica	400	C	16	35	0.034	0.48
Hippocratea spp	200	C	8	17.48	0.031	9.54
Total	1144			100.06	ΣC = 0.325	99.93

Key for indication: Source: (Lind EM and Morrison MES 1974; Beentje HJ 1994)
Important Value Index = 100.06 +99.93=200% or 2
Dominant' Shrub – *Rhus natalensis*
Grass – *Melinus minituflora*
Species diversity (H^1) D = =0.8
Temperature (dry bulb thermometer) = 24^0c
(Wet bulb thermometer) = 19^0c
Relative humidity = 5^0c

Hippocratea spp of the forest associations with climbers spanning the different canopy layers. Species diversity was higher due to heterogeneity of the physical environments, climatic conditions and the complexity of the vertical structure of different habitat. The Saiwa swamp bushed-grassland has the species diversity value of 0.8 and dominance index value of 0.2. *Hyperenia roofer, Hyperenia pendipula, Commelina africana, Solanum* spp, *Anjiuga remota, Leonatis* spp, *and other Hyperenia* species *were highly* dominant plant species (Tables 1b, 2 and 3). *Leonatis species* was relatively common in both ecosystems. The Saiwa swamp had an almost equal distribution of shrubs, grasses and climbers species diversity compared to Kakamega forest grassland community.

DISCUSSION

Past research has shown that the ecosystems are organized to support high species diversity and richness in the setting where they evolved (Hamilton 1984; Hamilton and Bensted 1990; Howard 1991; Lovett and Wasser 1993; Chapin et al. 1996; Burgess and Clarke 2000; Chapin et al. 2002; Newmark 2002). They further revealed that most forests have lost biodiversity value over the past hundred years of management under government control. However, despite the fears from these researchers, present research shows that Kakamega forest grassland community still has the highest species diversity compared to Saiwa Swamp National Park grassland community as depicted by species diversity values (Tables1b and 3).

The Saiwa swamp grassland community is also rich in species (0.8H') but not higher compared to Kakamega forest community with the highest species diversity of 0.9 (H'). Indeed species richness recorded for both Kakamega grassland and Saiwa National lies within the range reported for tropical forests, often higher than 0.5 (Lind and Morrison 1974, Githae et al. 2007), and falls within range of most East African forests (e.g. Linder 2001). Previous research (Mutangah et al. 1992) recorded 147 plant species in Kakamega tropical rainforest whereas Blackett (1994) recorded 161 species in Mt. Kenya moist montane forest. The highest documented species richness in any of Kenya's indigenous forests was 280 plant species for the Mau Forest Reserve Complex, which covers an area of about 360,000 ha (Mutangah et al. 1993). But once the biodiversity index were calculated, the values are within the ones reported herein. The results of current experiments show that both sites had diversity indices 0.9 (Table 1b)

and 0.8 (Table 3) for Kakamega and Saiwa Swamp respectively; and these results are in line with previous findings of the Kakamega tropical rain forest fragments of Buyangu and Isecheno, which were 0.80 and 0.84, respectively (Fashing and Gathua 2004). Because of the current world wide loss of biodiversity that seriously threatens the services of well-functioning ecosystems that provide to humanity (Chapin et al. 2000; Luck et al. 2003); preserving biodiversity is paramount to preservation of humanity. With the information derived from present research, the policy makers and conservationists can strengthen the protection and enhance the re-establishment of the species endemic to these areas for sustainability.

CONCLUSION

There was a sharp transition between Kakamega forest grassland community and Saiwa Swamp National Park grassland communities. This is because Kakamega Forest grassland is classified as a tropical rainforest with highest species rich in flora and fauna compared to Saiwa Swamp National Park yet both of them are highly protected by the government. The Saiwa Swamp National Park can be classified as tropical riverine forest. Both areas have climbers and lianas and epiphytes. Kakamega forest consists of primary forest while Saiwa Swamp National Park is a secondary forest. In essence, both ecosystems had high diversity indices and the species richness is still high and the management should therefore just enhance the same conservation strategy.

Therefore, the study recommends further research to be carried out to study likely effects of species loss more specifically (i.e. effects of specific species in specific ecosystems such as in forest, grassland and bush-land eco-systems) where human encroachment is common and likely regeneration of the previously disturbed forests in both Kakamega and Saiwa national park.

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