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Plant Species Diversity along Road Reserve in Kisumu County-Kenya

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ABSTRACT

Kisumu County has very minimal assessment of the local flora, with only scanty information from protected areas such as Ndere Island. There is no information on the roadside flora, yet road reserves are better conduit for biodiversity conservation due to limited human interference. This study assessed the role of a road reserve in conservation of floral diversity within Kisumu County. Species sampling was by transect method while percentage cover was by point quadrat method for grasses and herbs and total head count method for trees. Species identification was based on morphological attributes according to ICBN. A total of 133 plants were sampled from 45 families. The therophytes (19.8%) dominated in terms of cover, while, the microphanerophytes (18 species) dominated in species abundance. Fabaceae (20 species) had the highest number of species, though; Poaceae had the highest ground cover (15.7%).

Key words: Kenya, diversity, road reserve, Fabaceae, Poaceae

INTRODUCTION

The distribution and abundance of invasive species can be influenced by the presence of corridors and habitat suitability which facilitate dispersal of propagules. Species invasion usually result from environmental and anthropogenic factors such as disturbance, proximity to roads, nutrient availability, topography and habitat fragmentation (Brothers and Spingarn, 1992; Cadenasso and Pickett, 2001; Gelbard and Belnap, 2003). Roads also influence the spread and growth of species by serving as corridors for movement as well as providing habitat for establishment of propagules (Christen and Matlack, 2009). Propagules of invasive species may be accidentally spread during road construction and maintenance. Road graders and other maintenance equipments used during the operation can act like plows, pushing seeds along the road (Gelbard and Belnap, 2003; Ferguson *et al*., 2002; Hansen and Clevenger, 2005; Spooner, 2005). Some studies have also shown that plant propagules can be transported on vehicles (Forman *et al*., 2002; Pickering and Mount, 2010). Non native species are more likely to occur along roadsides and their probability of establishing in the interior is generally lower (Ferguson *et al*., 2002; Hansen and Clevenger, 2005). Culvert outwashes usually facilitate the movement of propagules off the road and roadways often serve as dispersal vectors within a region at both landscape and local scale (Flory and Clay, 2006).

Roadsides have different environmental conditions in terms of altered light availability, soil texture, compaction and chemistry; water regimes such as increased water runoff and repeated distribution for maintenance and off road driving when compared to adjacent native vegetation

(Gelbard and Belnap, 2003; Hansen and Clevenger, 2005). Non native species may respond better than the indigenous species to the alien substrates altered disturbance, water and nutrient regimes found on roadsides. Upon their establishment on the roadside, they begin spreading interior over time (Pauchard and Alaback, 2004).

There are fewer publications in Kisumu County on assessment of the local flora (Agnew and Agnew, 1994; Arwa, 2005; Beentje, 1994; Kokwaro, 1993). There, however seems to be no information on floral diversity a long road reserves either protected or accidentally conserved. Most of the documented studies on species diversity available are on government protected sites such as Kakamega Forest and Mau Forest in the neighbouring Counties (KIFCON., 1994; Onyango *et al*., 2004). This study assessed the floral diversity along a road reserve within Kisumu County-Kenya as a way of recognizing their role in conservation of plant species. As a consequence, we developed a checklist on plant species diversity along Kisumu-Busia road reserve within Kisumu County with emphasis on plant habits, familial and species compositions.

MATERIALS AND METHODS

Study area: The study sites are located along the Kisumu-Busia Highway but within Kisumu County (0.1000° S, 34.7500° E) (Ojany and Ogendo, 1973) (Fig. 1), Kenya. The study was conducted in 7 blocks of land (sites) covering a total area of 60, 000 m^2 along the highway from (00°06'00" S, 34°45'00" E) to (00°02'00" N, 34°35'00" E). The largest block was approximately 18, 000 m^2, while the smallest was about 5, 000 m^2. Since, all the study sites were on the road reserve (12 m from the highway), human activities were very limited due to security concerns and also given that all the reserves in Kenya are owned by the government. Consequently, the blocks represent abandoned pieces of land where only minimal cattle grazing and firewood collection take place occasionally. The study sites were characterized by large rock out-crops and road construction debris that supported plant growth. This gave the sites an elevation of approximately 30 m above the highway

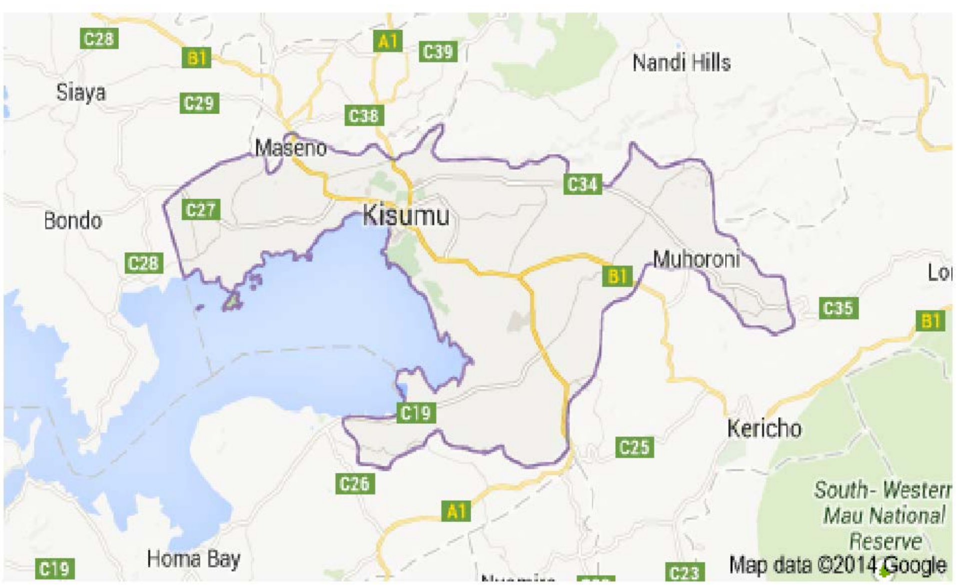

Fig. 1: Map of Kasumu country showing the road under study (marked B1) between Kisumu and Maseno

level (1131-1501 m) from Kisumu town to the County Boundary Northwards. The soils were sandy with overlapping ferralsols from Mount Elgon eruptions in certain parts. The sites were rich in floral composition, what could likely be attributed to the limited human access to the areas prompted by their elevation, thus the accidental conservation. The study sites were commonly dominated by plant species such as *Tithonia diversifolia* (Helmsl) A. Gray and *Calamintha nepeta* (L) Savi by the road side and tree species such as *Albizia coriara* Welw. Ex. Oliv. and *Markhamia lutea* (Benth.) K. Schuman at the elevation peaks. The rock surfaces and tree barks were covered by species of moss such as: *Campylopus arctocarpus* (Hornsch.) Mitt, *Epipordium becarii* (Mull. Hal). Ex Venturi and *Rhynchostegium comorae* (Mull. Hal.) A. Jaeger among others. The areas adjacent to both roads were dominated by invasive species such as *Ipomoea hildelbrandtii* Vatke, *Calamintha nepeta* (L) Savi, *Tithonia diversifolia* (Helmsl) A. Gray and *Lantana camara* L. which could have developed as a result of accidental movement of plant propagules by road construction machines (Christen and Matlack, 2009).

Sampling method: The sites were stratified into three categories (1) Foot hill, (2) Escarpment and (3) Hill top. Sampling for plant species diversity was by transect method while percentage cover was done using point frame quadrat method for grasses and herbaceous species. Total head count method was also used to estimate percentage cover for trees. Five transects, 2 at the foot hill, 1 at the escarpment and 2 at the hill top, each measuring 2×20 m were randomly laid in each block along the highway to estimate species diversity. The invasive species were identified according to the (GISIN., 2008) invasive species list. Plant life form spectrum analysis was based on and (Govaerts *et al*., 2000) systems. Data on percentage composition was collected using 5 quadrats measuring 2×2 m from all transects within a block. Samples were identified based on their morphological attributes according to ICBN and then deposited to the East Africa Herbarium, in The National Museum of Kenya.

RESULTS

From the study, a total of 133 plant species were sampled belonging to 45 different plant families (Table 1). Most species were erect while some were climbers and scramblers with a few lianas. Twenty invasive species were reported from the study as the rest (93) were non invasive (Table 1). The ten most species rich families included: Fabaceae (20 species), Euphorbiaceae (10 species), Asteraceae (9 species), Malvaceae (9 species), Verbenaceae (8 species), Rubiaceae (7 species), Lamiaceae (5 species), Poaceae (5 species), Vitaceae (5 species) and Apocynaceae (5 species) (Table 2). Families such as Acanthaceae, Cyperaceae, Moraceae and Solanaceae among others (Table 2) reported one species each and were considered as the least species rich families. The families with the highest percentage ground cover included; Poaceae (15.7%), Asteraceae (10.087%), verbenaceae (9.389%) and Lamiaceae (9.2%) as shown in Table 2. Families such as, Orchidaceae (0.139%) and Ranunculaceae (0.139%) recorded the lowest percentage ground cover (Table 2). In terms of the life forms, the therophytes (19.8%) had the highest percentage composition followed by the microphanerophytes (18.8%), nanophanerophytes (18.4%), while, the epiphytes (0.1%) recorded the lowest composition (Fig. 2). On the other hand, the microphanerophytes had the largest number of families (17 families), followed by the mesophanerophytes (13 families), the epiphytes (1) had the least number of species (Fig. 3). The

Table 1: Checklist of plant species sampled

Family	Plant name	Life forms	Nature	Cover (%)	Species voucher No.
Acanthaceae	*Hypoestes aristata* (Vahl).Sol. ex Roem and Schult	Nanophanerophyte	Non-invasive	0.325	AODO/09/NMK/08/08/2012
Agavaceae	*Agave sisalina* Perrine	Geophyte	Non-invasive	0.511	AODO/02/NMK/08/08/2012
Aloaceae	*Aloe secundiflora* Engl	Geophyte	Non-invasive	0.279	AODO/03/NMK/08/08/2012
Anarcadiaceae	*Rhus natalensis* Krauss	Microphanerophyte	Non-invasive	2.232	AODO/04/NMK/08/08/2012
Anarcadiaceae	*Rhus quartiniana* A. Rich	Microphanerophyte	Non-invasive	0.604	AODO/05/NMK/08/08/2012
Anarcadiaceae	*Rhus vulgaris* Meikle	Microphanerophyte	Non-invasive	1.534	AODO/06/NMK/08/08/2012
Annonacceae	*Annona senegalensis* Pers. Ssp. *senegalensis*	Microphanerophyte	Non-invasive	0.511	AODO/08/NMK/08/08/2012
Apiaceae	*Heteromorpha trifoliata* (Wendl.) Eckl. and Zeyh.	Microphanerophyte	Non-invasive	0.093	AODO/10/NMK/08/08/2012
Apiaceae	*Steganotaenia araliacea* Hochst.	Mesophanerophyte	Non-invasive	0.744	AODO/12/NMK/08/08/2012
Apocynaceae	*Baissea multiltiflora* A.D.C.	Microphanerophyte	Non-invasive	0.372	AODO/13/NMK/08/08/2012
Apocynaceae	*Carissa bispinosa;* (L.) Desf.	Microphanerophyte	Non-invasive	0.372	AODO/15/NMK/08/08/2012
Apocynaceae	*Carissa edulis* (Forsk.) Vahl	Microphanerophyte	Non-invasive	0.744	AODO/14/NMK/08/08/2012
Apocynaceae	*Catharanthus roseus* (L.) G.Don	Nanophanerophyte	Invasive	0.139	AODO/16/NMK/08/08/2012
Araliaceae	*Hydrocotyle sibthorpioides* Lam	Liana	Non-invasive	0.511	AODO/11/NMK/08/08/2012
Asteraceae	*Ageratum conyzoides* L.	Chamaephyte	Invasive	1.720	AODO/17/NMK/08/08/2012
Asteraceae	*Ageratum mexicana* Mill	Chamaephyte	Non-invasive	0.558	AODO/18/NMK/08/08/2012
Asteraceae	*Aspilia pluriseta* Schweinf	Therophytes	Invasive	0.883	AODO/19/NMK/08/08/2012
Asteraceae	*Conyza stricta* Willd	Nanophanerophyte	Invasive	0.976	AODO/20/NMK/08/08/2012
Asteraceae	*Emilia discofolia* (Oliv.) C. Jeffrey	Therophyte	Invasive	0.697	AODO/21/NMK/08/08/2012
Asteraceae	*Erlengea calycina* (S. Moore)	Therophyte	Non-invasive	0.279	AODO/22/NMK/08/08/2012
Asteraceae	*Tithonia diversifolia* (Hemsl.) A. Gray	Nanophanerophyte	Invasive	4.277	AODO/23/NMK/08/08/2012
Asteraceae	*Vernonia amygdalina* Delile	Microphanerophyte	Non-invasive	0.604	AODO/25/NMK/08/08/2012
Asteraceae	*Vernonia laspius* O. Hoffm.	Microphanerophyte	Non-invasive	0.093	AODO/26/NMK/08/08/2012
Bignoniaceae	*Markhamia lutea* (Benth.) K. Schum.	Mesophanerophyte	Non-invasive	0.465	AODO/27/NMK/08/08/2012
Bignoniaceae	*Spathodea campanulata* P. Beauv.	Mesophanerophyte	Invasive	0.325	AODO/29/NMK/08/08/2012
Brassicaceae	*Cardamine trichocarpa* A. Rich	Nanophanerophyte	Non invasive	0.604	AODO/28/NMK/08/08/2012
Celesteraceae	*Mystroxylon aethiopicum* (Thunb.) Loes.	Microphanerophyte	Invasive	0.186	AODO/30/NMK/08/08/2012
Clausiaceae	*Garcinia buchananni* Bak.	Mesophanerophyte	Non invasive	0.186	AODO/32/NMK/08/08/2012
Colchicaceae	*Gloriosa superb*a L.	Liana	Non-invasive	0.279	AODO/69/NMK/08/08/2012
Combretaceae	*Combretum collinum* Fres.	Mesophanerophyte	Non-invasive	1.069	AODO/31/NMK/08/08/2012
Combretaceae	*Combretum molle* G.Don.	Mesophanerophyte	Non-invasive	1.441	AODO/09/NMK/08/08/2012
Commelinaceae	*Commelina africana* L.	Liana	Non-invasive	0.186	AODO/33/NMK/08/08/2012
Convolvulaceae	*Ipomoea hildebrandtii* Vatke	Nanophanerophyte	Invasive	2.743	AODO/32/NMK/08/08/2012
Convolvulaceae	*Ipomoea kituiensis* Vatke	Nanophanerophyte	Invasive	0.372	AODO/35/NMK/08/08/2012
Cyperaceae	*Cyperus rotundus* L.	Therophyte	Non-invasive	0.186	AODO/34/NMK/08/08/2012
Dracaenaceae	*Sansevieria suffruticosa* N.E.Br.	Geophyte	Non-invasive	0.139	AODO/01/NMK/08/08/2012
Ebenaceae	*Diospyros abyssinica* (Hiern) F. White	Mesophanerophyte	Non invasive	0.325	AODO/36/NMK/08/08/2012
Ebenaceae	*Diospyros mespiliformis* Hochst ex A.D.C.	Mesophanerophyte	Non invasive	0.093	AODO/37/NMK/08/08/2012
Ebenaceae	*Euclea divinorum* Hiern	Microphanerophyte	Non-invasive	1.348	AODO/39/NMK/08/08/2012
Euphorbiaceae	*Antidesma venosum* Tul.	Microphanerophyte	Non-invasive	0.139	AODO/38/NMK/08/08/2012
Euphorbiaceae	*Bridelia micrantha* (Hochst.) Baill	Mesophanerophyte	Non-invasive	1.209	AODO/40/NMK/08/08/2012
Euphorbiaceae	*Croton dictygamus* Pax	Mesophanerophyte	Non invasive	0.558	AODO/41/NMK/08/08/2012
Euphorbiaceae	*Euphorbia candelabrum* Tremaux ex. Kotschy	Mesophanerophyte	Non-invasive	0.372	AODO/42/NMK/08/08/2012
Euphorbiaceae	*Euphorbia hirta* L.	Chamaephyte	Non-invasive	1.627	AODO/43/NMK/08/08/2012
Euphorbiaceae	*Euphorbia prostrata* Ait.	Chamaephyte	Non-invasive	0.465	AODO/44/NMK/08/08/2012
Euphorbiaceae	*Phyllanthus fischeri* Pax.	Microphanerophyte	Non-invasive	0.186	AODO/45/NMK/08/08/2012
Euphorbiaceae	*Phyllanthus odontadenius* Muell. Arg.	Microphanerophyte	Non-invasive	0.139	AODO/46/NMK/08/08/2012

Table 1: Continue

Family	Plant name	Life forms	Nature	Cover (%)	Species voucher No.
Euphorbiaceae	*Phyllanthus suffrutescens* Pax	Microphanerophyte	Non-invasive	0.045	AODO/47/NMK/08/08/2012
Euphorbiaceae	*Ricinus communis* L.	Microphanerophyte	Non-invasive	0.744	AODO/48/NMK/08/08/2012
Fabaceae	*Abrus precatorius* L.	Liana	Non-invasive	0.651	AODO/57/NMK/08/08/2012
Fabaceae	*Acacia Senegal* Linn	Mesophanerophyte	Non-invasive	0.186	AODO/58/NMK/08/08/2012
Fabaceae	*Acacia seyal* Del.	Mesophanerophyte	Non-invasive	0.186	AODO/59/NMK/08/08/2012
Fabaceae	*Albizia coriara* Oliv	Mesophanerophyte	Non-invasive	0.604	AODO/55/NMK/08/08/2012
Fabaceae	*Caesalpinia decapetala* (Roth) Alston	Liana	Non-invasive	0.465	AODO/49/NMK/08/08/2012
Fabaceae	*Chamaecrista mimosoides* (L.) Greene	Chamaephyte	Non-invasive	0.883	AODO/50/NMK/08/08/2012
Fabaceae	*Crotalaria agatiflora* Scheinf.	Therophyte	Non-invasive	1.581	AODO/61/NMK/08/08/2012
Fabaceae	*Crotalaria ochroleuca* G. Don	Therophyte	Non-invasive	0.139	AODO/62/NMK/08/08/2012
Fabaceae	*Desmodium repandum* (Vahl) DC.	Therophyte	Non-invasive	0.093	AODO/63/NMK/08/08/2012
Fabaceae	*Desmodium uncinatum* (Jacq.) D.C.	Therophyte	Non-invasive	0.139	AODO/64/NMK/08/08/2012
Fabaceae	*Erythrina abysinica* DC.	Mesophanerophyte	Non-invasive	0.139	AODO/56/NMK/08/08/2012
Fabaceae	*Glycine wightii* (Wight and Arn.) Verdc.	Therophyte	Non-invasive	1.627	AODO/65/NMK/08/08/2012
Fabaceae	*Indogofera arrecta* A. Rich	Nanophanerophyte	Non-invasive	1.441	AODO/66/NMK/08/08/2012
Fabaceae	*Mimosa pudica* L.	Therophyte	Non-invasive	0.697	AODO/60/NMK/08/08/2012
Fabaceae	*Rynchosia hirta* (Andrews) Meikle and Verdc.	Liana	Non-invasive	0.093	AODO/67/NMK/08/08/2012
Fabaceae	*Senna occidentalis* (L.) Link	Therophyte	Non-invasive	0.976	AODO/51/NMK/08/08/2012
Fabaceae	*Senna siamea* (Larmarck) H.S. Irwin and Barneby	Mesophanerophyte	Non-invasive	0.139	AODO/52/NMK/08/08/2012
Fabaceae	*Senna spectabilis* (DC.) H.S. Irwin and Barneby	Mesophanerophyte	Non-invasive	0.186	AODO/53/NMK/08/08/2012
Fabaceae	*Tylosemma fassoglense* (Kotschy ex Schweinf)	Liana	Non-invasive	0.651	AODO/54/NMK/08/08/2012
Fabaceae	*Vigna schimperi* Bak.	Therophyte	Non-invasive	0.651	AODO/68/NMK/08/08/2012
Lamiaceae	*Calamintha nepeta* (L) Savi	Therophyte	Invasive	3.161	AODO/70/NMK/08/08/2012
Lamiaceae	*Hoslundia opposita* Vahl.	Nanophanerophyte	Non-invasive	1.209	AODO/71/NMK/08/08/2012
Lamiaceae	*Leonotis nepetifolia* (L.) Ait.f.	Microphanerophyte	Invasive	1.58	AODO/72/NMK/08/08/2012
Lamiaceae	*Ocimum kilimandscharicum* Guerke	Nanophanerophyte	Invasive	1.674	AODO/73/NMK/08/08/2012
Lamiaceae	*Plectranthus longipes* Bak.	Therophyte	Non-invasive	1.581	AODO/74/NMK/08/08/2012
Malvaceae	*Abutilon mauritianum* (Jacq.) Medic.	Microphanerophyte	Non-invasive	0.558	AODO/75/NMK/08/08/2012
Malvaceae	*Hibiscus articulatus* Hochst ex A. Rich.	Nanophanerophyte	Non-invasive	0.279	AODO/76/NMK/08/08/2012
Malvaceae	*Hibiscus fuscus* Garcke	Chamaephyte	Non-invasive	0.79	AODO/77/NMK/08/08/2012
Malvaceae	*Sida acuta* Burm.f.	Chamaephyte	Non-invasive	1.627	AODO/78/NMK/08/08/2012
Malvaceae	*Sida ovata* Forssk.	Chamaephyte	Non-invasive	0.046	AODO/79/NMK/08/08/2012
Malvaceae	*Urena lobataI* L.	Chamaephyte	Non-invasive	0.232	AODO/80/NMK/08/08/2012
Malvaceae	*Grewia bicolor* Juss.	Microphanerophyte	Non-invasive	1.209	AODO/117/NMK/08/08/2012
Malvaceae	*Grewia forbesii* Mast.	Microphanerophyte	Non-invasive	0.372	AODO/118/NMK/08/08/2012
Malvaceae	*Triumfetta rhomboideae* Jacq.	Therophyte	Non-invasive	0.511	AODO/119/NMK/08/08/2012
Meliaceae	*Melia azedarach* Knox	Mesophanerophyte	Non-invasive	0.186	AODO/81/NMK/08/08/2012
Meliaceae	*Turraea robustus* Guerke	Mesophanerophyte	Non invasive	0.372	AODO/82/NMK/08/08/2012
Moraceae	*Ficus sycomorus* L.	Mesophanerophyte	Non-invasive	0.232	AODO/83/NMK/08/08/2012
Myrtaceae	*Psidium guajava* L.	Microphanerophyte	Non-invasive	1.069	AODO/84/NMK/08/08/2012
Myrtaceae	*Syzigium cumini* (L.) Skeels	Mesophanerophyte	Non-invasive	0.651	AODO/85/NMK/08/08/2012
Oleaceae	*Jasminum abysinicum* DC.	Liana	Non-invasive	0.186	AODO/86/NMK/08/08/2012
Oleaceae	*Jasminum floribundum* Fresen.	Liana	Non-invasive	0.186	AODO/87/NMK/08/08/2012
Opiliaceae	*Opilia amentacea* Roxb.	Microphanerophyte	Non-invasive	0.093	AODO/88/NMK/08/08/2012
Orchidaceae	*Epipactis africana* Rendle	Epiphyte	Non-invasive	0.139	AODO/89/NMK/08/08/2012
Papaveraceae	*Argemone mexicana* L.	Therophyte	Non-invasive	0.372	AODO/90/NMK/08/08/2012
Piperaceae	*Piper capense* L.f.	Liana	Non-invasive	0.093	AODO/91/NMK/08/08/2012
Poaceae	*Eragrostis tenuifolia* (A.Rich) Steud.	Therophyte	Non-invasive	2.047	AODO/96/NMK/08/08/2012

Table 1: Continue

Family	Plant name	Life forms	Nature	Cover (%)	Species voucher No.
Poaceae	*Hyparrhenia rufa* (Nees*)* Stapf	Therophyte	Invasive	3.626	AODO/95/NMK/08/08/2012
Poaceae	*Imperata cylindrica* (L.) Raeuschel	Geophyte	Invasive	3.458	AODO/92/NMK/08/08/2012
Poaceae	*Panicum maximum* Jacq.	Hemicryptophyte	Invasive	2.696	AODO/93/NMK/08/08/2012
Poaceae	*Themeda triandra* Forsk.	Hemicryptophyte	Invasive	3.905	AODO/94/NMK/08/08/2012
Ranunculaceae	*Clematis cordifolia* L. D.C	Liana	Non-invasive	0.744	AODO/97/NMK/08/08/2012
Ranunculaceae	*Clematis hirsuta* Gull. and Perr.	Liana	Non-invasive	0.093	AODO/98/NMK/08/08/2012
Ranunculaceae	*Clematis simensis* Fres.	Liana	Non-invasive	0.093	AODO/99/NMK/08/08/2012
Rhamnaceae	*Ziziphus abbysinica* A. Rich	Microphanerophyte	Non-invasive	0.5	AODO/111/NMK/08/08/2012
Rhamnaceae	*Ziziphus mucronata* Willd.	Microphanerophyte	Non-invasive	0.046	AODO/112/NMK/08/08/2012
Rosaceae	*Prunus africana* (Hoof.f.) Kalkm.	Mesophanerophyte	Non-invasive	0.465	AODO/100/NMK/08/08/2012
Rubiaceae	*Galium simense* Fres.	Liana	Non invasive	0.046	AODO/101/NMK/08/08/2012
Rubiaceae	*Keetia guienzii* (Sond.) Bridson	Mesophanerophyte	Non-invasive	0.186	AODO/102/NMK/08/08/2012
Rubiaceae	*Pentas lanceolata* (Forsk.) Deflers	Nanophanerophyte	Non-invasive	0.232	AODO/103/NMK/08/08/2012
Rubiaceae	*Rubia cordifolia* L.	Liana	Non-invasive	0.093	AODO/104/NMK/08/08/2012
Rubiaceae	*Tarenna graveolens* (S. Moore) Brem.	Microphanerophyte	Non-invasive	0.279	AODO/105/NMK/08/08/2012
Rubiaceae	*Vanguera apiculata* K. Schum.	Nanophanerophyte	Non-invasive	0.209	AODO/106/NMK/08/08/2012
Rubiaceae	*Vanguera volkensii* K. Schum.	Microphanerophyte	Non-invasive	0.209	AODO/133/NMK/08/08/2012
Rutaceae	*Teclea nobilis* Del.	Microphanerophyte	Non-invasive	1.302	AODO/108/NMK/08/08/2012
Rutaceae	*Toddalia asiatica* Del.	Liana	Non-invasive	0.744	AODO/109/NMK/08/08/2012
Sapindaceae	*Cardiospermun halacacabun* Linn.	Liana	Non-invasive	0.418	AODO/24/NMK/08/08/2012
Simaroubaceae	*Harrisonia abbysinica* Oliv.	Microphanerophyte	Non-invasive	0.325	AODO/107/NMK/08/08/2012
Smilacaceae	*Smilax anceps* (Willd.*S.*)	Chamaephyte	Non invasive	0.279	AODO/113/NMK/08/08/2012
Solanaceae	*Solanum incanum* L.	Chamaephyte	Invasive	2.603	AODO/114/NMK/08/08/2012
Sterculiaceae	*Hermania alhensis*	Nanophanerophyte	Non-invasive	0.372	AODO/115/NMK/08/08/2012
Sterculiaceae	*Waltheria indica* L.	Therophyte	Non-invasive	0.458	AODO/116/NMK/08/08/2012
Verbenaceae	*Rotheca myricoides* (Hochst) Steane and Mabb	Microphanerophyte	Non-invasive	1.162	AODO/120/NMK/08/08/2012
Verbenaceae	*Lantana camara* L.	Nanophanerophyte	Invasive	1.906	AODO/124/NMK/08/08/2012
Verbenaceae	*Lantana rhodesiensis* Moldenke	Nanophanerophyte	Non-invasive	0.837	AODO/125/NMK/08/08/2012
Verbenaceae	*Lantana trifolia* L.	Nanophanerophyte	Non-invasive	0.79	AODO/126/NMK/08/08/2012
Verbenaceae	*Priva curtisiae* Kobuski	Chamaephyte	Invasive	3.3	AODO/127/NMK/08/08/2012
Verbenaceae	*Vitex doniana* Sweet	Mesophanerophyte	Non-invasive	0.697	AODO/121/NMK/08/08/2012
Verbenaceae	*Vitex keniensis* Turril	Mesophanerophyte	Non-invasive	0.604	AODO/122/NMK/08/08/2012
Verbenaceae	*Vitex payos* (Lour) Merr	Mesophanerophyte	Non-invasive	0.093	AODO/123/NMK/08/08/2012
Vitaceae	*Cissus rotundifolia* (Forsk) Vahl	Liana	Non-invasive	0.325	AODO/128/NMK/08/08/2012
Vitaceae	*Cyphostemma maranguense* (Gilg) Descoigns	Liana	Non invasive	0.558	AODO/129/NMK/08/08/2012
Vitaceae	*Cyphostemma orondo* (Gilg and Brandt.)	Liana	Non invasive	0.139	AODO/130/NMK/08/08/2012
Vitaceae	*Cyphostemma serpens* (A. Rich) Descoigns	Liana	Non invasive	0.139	AODO/131/NMK/08/08/2012
Vitaceae	*Rhoicissus tridentata* (L.F.) Wild and Drum	Liana	Non-invasive	0.232	AODO/132/NMK/08/08/2012

hemicryptophytes (1 family) and epiphytes (1 family) recorded the lowest number of families in their categories (Fig. 3). The ten most dominant plant species in the area included: *Tithonia diversifolia* (Hemsl.) A. Gray (4.28%), *Themeda triandra* Forsk (3.9%), *Hyparrhenia rufa* (Nees) Stapf (3.63%), *Imperata cylindrica* (L) Raeuschel (3.5%), *Priva curtisiae* Kobuski (3.3%), *Calamintha nepeta* (L) Savi (3.2%), *Ipomea hidelbrandtii* Vatke (2.7%), *Panicum maximum* Jacq. (2.7%), *Solanum incanum* L. (2.6%) and *Rhus natalensis* Kraus (2.2%) (Table 1). The distribution of *Tithonia diversifolia, Priva curtisiae* and *Calamintha nepeta* and some other highly invasive species (Table 1) decreased from the road.

Table 2: Species composition per plant family

Plant families	No. of species	Total composition (%)
Acathanceae	1	0.325
Agavaceae	1	0.511
Aloaceae	1	0.279
Anarcadiaceae	3	4.370
Annonaceae	1	0.511
Apiaceae	2	0.837
Apocynaceae	4	1.627
Araliaceae	1	0.511
Asteraceae	9	10.087
Bignoniaceae	2	0.790
Brassicaceae	1	0.604
Celesteraceae	1	0.186
Clusiaceae	1	0.186
Colchicaceae	1	0.279
Combretaceae	2	2.510
Commelinaceae	1	0.186
Convolvulaceae	2	3.115
Cyperaceae	1	0.186
Dracaenaceae	1	0.139
Ebenaceae	3	1.766
Euphorbiaceae	10	5.484
Fabaceae	20	11.527
Lamiaceae	5	9.205
Malvaceae	9	5.624
Meliaceae	2	0.558
Moraceae	1	0.232
Myrtaceae	2	1.720
Oleaceae	2	0.372
Opiliaceae	1	0.093
Orchidiaceae	1	0.139
Papaveraceae	1	0.352
Piperaceae	1	0.093
Poaceae	5	15.732
Ranunculaceae	3	0.186
Rhamnaceae	2	0.666
Rosaceae	1	0.465
Rubiaceae	7	1.254
Rutaceae	2	2.046
Sapindiaceae	1	0.418
Simaroubaceae	1	0.325
Smilaceae	1	0.279
Solanaceae	1	2.603
Sterculaceae	2	0.830
Verbenaceae	8	9.389
Vitaceae	5	1.393
45 families	133	100.00

DISCUSSION

Most plant species dominating the roadside were found to be invasive and there was a high likelihood that their distribution could have resulted from road construction. This is evidenced by the fact that away from the road, the number of species declined. Such a finding has been reported in some parts of the world where it was revealed that most species found along roads were invasive and mostly distributed seeds, runners and rhizomes (Forman and Alexander, 1998) transported by road construction machines (Forman *et al.*, 2002; Pickering and Mount, 2010; Pauchard and Alaback, 2004). *Tithonia diversifolia, Priva curtisiae* and *Calamintha nepeta* (Table 1) were the most dominant species along Kisumu-Busia road with relatively higher percentage composition. These plant species were persistent on the road reserve for quite a long

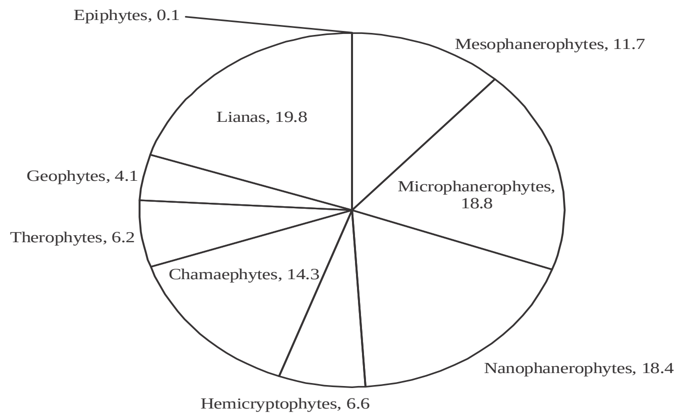

Fig. 2: Life form spectrum analysis of plant species (in percentage) found in a road reserve within Kisumu country

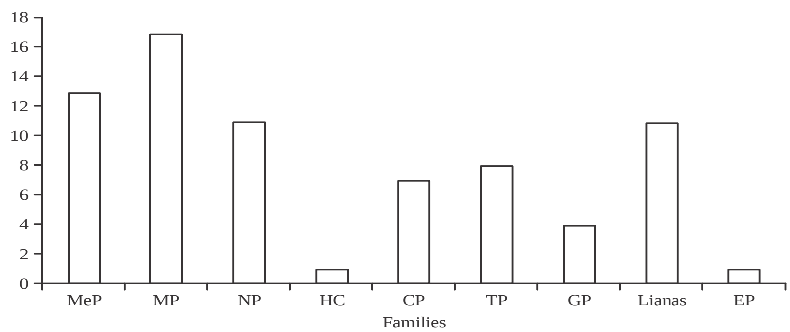

Fig. 3: Familial composition of plant life forms in a road reserve within in Kisumu country, MeP: Mesophanerophytes, MP: Microphanerophytes, NP: Nanophanerophytes, HC: Hemicryptophytes, Cp: Chamaephytes, TP: Therophytes, GP: Geophytes, Ep: Epiphytes

time and attempts to maintain the road failed to eliminate them completely. Thus, the main reason they flourish in spite of continuous clipping by construction machines during maintenance. Similar findings have also been reported in Tanzania (Mollel *et al*., 2012) and other parts of the world where the above plants among other invasive species have dominated roadsides (Forman *et al*., 2002; Holway *et al*., 2002; Moktan and Das, 2013). Besides the road construction machines, these plants have also been reported to have a facilitated means of spreading their propagules such as seeds with a lot of ease (Pauchard and Alaback, 2004). The therophytes (19.8%), microphanerophytes (18.8%), nanophanerophytes (18.4%) and chamaephytes (14.3%) were the most dominant life forms recorded from the study area. However, in terms of species composition, the microphanerophytes (17 species), were the most dominant followed by mesophanerophytes (13 species), nanophanerophytes (11 species) and therophytes (8 species) among others (Fig. 3). The therophytes mostly constituted the annual herbaceous species that bore seeds and were very prolific in their reproduction. The microphanerophytes and nanophanerophytes delimited the herbs and shrubs based on their heights ranging from 30-8 m. The chamaephytes included the lowly herbaceous species with perrenating buds located closer to the ground surface (less than 30 cm).

Several studies on biodiversity have reported different findings on the most dominant life forms, based on the classification system used climatic conditions of the area and the nature of the ecosystem under study. For instance, most tropical ecosystems (Batalha and Martins, 2004; Koulibaly *et al*., 2006; Ouedraogo *et al*., 2011; Schmidt *et al*., 2005) have ascertained that the phanerophytes are the most dominant life form especially in the forested regions. In most savannas ecosystems however, the therophytes (Aghaei *et al*., 2013; Medvecka *et al*., 2013; Turki and El Shayeb, 2005), chamaephytes (Gimenez *et al*., 2004) and hemicryptophytes (Amjad, 2012; Dimopoulos and Georgiadis, 1992; Klimes, 2003) have been reported to dominate different regions depending on how well they interact with their environment (Zarezade *et al*., 2007). From our study, phanerophytes grouped together constituted 48.9%, which implied that they were the most dominant, however, there was need to delimit the groups (Govaerts *et al*., 2000) for ease of understanding, given the floral diversity of the study area.

The therophytes, microphanerophytes and nanophanerophytes that constituted over 50% of the total composition, were mostly herbaceous species and were sampled closer (within 3 m from the edge of the road) to the road as compared to other life forms such as mesophanerophytes. Such kind of life form distribution could be attributed to the routine road construction that takes about two years, a period that cannot allow the trees and higher shrubs to be fully established. This has also been reported in other studies where the shrubs (mostly nanophanerophytes and microphanerophytes) have been the most dominant plant form in terms of species diversity (Gautam *et al*., 2014; Schnitzer and Bongers, 2002; Schnitzer and Carson, 2000) especially in disturbed areas. The frequent disturbance on the roadside resulting from machines and pedestrians could have limited the distribution of most trees and shrubs to the elevated land. Elsewhere (Trombulak and Frissell, 2000; Gelbard and Belnap, 2003), it has been reported that clearing vegetation during road construction, addition of road fill and grading of unpaved roads have created areas of bare and deeper soils that allow exotic seeds of grasses, herbs and shrubs to be established (Cadenasso and Pickett, 2001; Gelbard and Belnap, 2003). The ease in dispersal of the propagules was attributed to the short life cycle of the plant forms and their invasive nature resulting from their adaptability to various soil types and production of high seed capacity (Williamson and Fitter, 1996; Zavaleta *et al*., 2001).

The 10 most dominant plant species colonizing the area (Table 1) were drawn from all life forms except the lianas, epiphytes and mesophanerophytes and the interesting feature is that they were mostly invasive. *Rhus natalensis*, even though dominant in the study area, is mostly distributed far distances from the edge of the road and this implies that the dispersal of its propagules could result from natural agents rather than those acting in the area and not necessarily road construction. *Tithonia diversifolia,* was the most dominant plant species in the study area (Table 1) and this could be attributed to its adaptive features that enables it to propagate both through seeds and also by vegetative means, hence the movement of its roots and other plant parts could lead to further regeneration of a whole plant (Oludare and Muoghalu, 2014; Wang *et al*., 2003). As a result of this adaptation, the plant was mostly found adjacent to the road as reported elsewhere (Chukwuka *et al*., 2007; Mollel *et al*., 2012; Wang *et al*., 2003) and not remotely within the road reserve. Fabaceae was the most dominant family with 20 plant species most of which were the therophytes and mesophanerophytes (Table 1 and 2), yet in terms of percentage composition, Poaceae was the most dominant (15.73%), in spite of its lower species abundance (5 plant species) (Table 1 and 2). The same trend was also observed in other plant families such as Euphorbiaceae (10 species), Asteraceae (9 species), Rubiaceae (7 species) and Verbenaceae (8 species) which were all more diverse (Table 2) compared to Poaceae family. The grasses constituted the highest ground cover (Table 1) and were distributed evenly which implied that they had well developed reproductive mechanisms that enabled them to propagate with a lot of ease within the ecosystem. These findings are in conformity with some studies conducted in Kenya and East African savannas and ranches on species diversity that revealed that grasses constitute the greatest percentage cover of floral diversity (Vanacker *et al*., 2005) due to their sensitivity to rainfall. Besides, some findings have revealed that *Imperata cylindrica* and *Themeda triandra* have higher percentage cover along highways and power lines (Goosen and Turton, 2006), what was attributed to the viability of their seeds and ease to disperse through wind (Cheplick, 2009). Parallel studies conducted elsewhere in various parts of Africa and globally (Mbayngone *et al*., 2008; Ouedraogo *et al*., 2011; Schmidt *et al*., 2007) have also shown that the family Fabaceae, Poaceae, Asteraceae, Cyperaceae and Eurphobiaceae are some of the most dominant (Schmidt *et al*. 2007), though depending on the climatic conditions, either Poaceae (Kabelo and Mafokate, 2004; Klaasen and Craven, 2003; Singh and Singh, 2014) or Fabaceae (Mbayngone *et al*., 2008; Ouedraogo *et al*., 2011; Schmidt *et al*., 2005; Schmidt *et al*., 2010) could be the most diverse. The diversity of the former, though accompanied with dominance of percentage cover is usually dependent on edaphic factors such as soil fertility and topography (Dukes, 2001). Research conducted on roadside plant species diversity in Arusha, Tanzania, revealed that family Asteraceae dominated the roadside vegetation followed by Fabaceae, Poaceae and Euphorbiaceae (Mollel *et al*., 2012).

Some studies conducted in Africa and other parts of the world have also confirmed that plant families such as Rubiaceae, Malvaceae and Lamiaceae also constitute a larger percentage of species in most ecosystem (Gaston, 2000; Mutke and Barthlott, 2005; Onyango *et al*., 2004; Schmidt *et al*., 2010). Other studies (Fridley, 2001; Johnson *et al*., 2008; Schwartz *et al*., 2000) have revealed that species diversity and percentage cover can differ depending on the ability of individual plant species to disperse and adapt to their surrounding environment as a result of varying edaphic factors. Further revelations have indicated that species composition and that of relatively few species is likely the best predictor of resource partitioning among plant species and not the number of local species (Johnson *et al*., 2008; Schwartz *et al*., 2000; Tilman *et al*., 1997). From the findings of this study, it was quite clear that the vegetation by the roadside did not vary much from that of the adjacent areas (mostly native) except for some invasive shrubs and herbs such as *Ageratum conyzoides, Mystroxylon aethiopicum* and *Ipomoea kituiensis* among others. The propagules of these species were highly likely to have been moved from other areas by road construction machines, thus limiting their distribution by the road side (Forman *et al*., 2002; Pickering and Mount, 2010). The slight difference in species composition could also be attributed to the variation in environmental condition and factors such as soil texture and compaction (Gelbard and Belnap, 2003) which might have hindered their spread remotely. This pattern in distribution of species by the roadside has been reported by similar studies conducted in other parts of the globe (Ferguson *et al*., 2002; Hansen and Clevenger, 2005). This trend if maintained through further protection, will greatly aid in the maintenance of taxa of conservation concern, thus increasing floral diversity within the country at large. This is possible since, the roads provide adequate landscape linkages that can be used in conservation networks.

CONCLUSION

Road reserves being corridors for conservation of species diversity should be given special consideration. This comes at a time when biodiversity loss has drawn the attention of very many conservationists especially in the areas perceived to be protected such as game reserves and parks whose accessibility are usually restricted. Plant species a long road reserves should be included in the National Biodiversity Conservation Strategies as a way of maintaining floral diversity within Kenya and Kisumu County. This way they will contribute valuable data that can supplement the currently available information on species diversity and also help to conserve some plant species that are considered threatened in the region. Besides, such measures will be essential in both current and future floral conservation.

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