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RESEARCH ARTICLE

REDLISTED SPECIES INKAYA MUHAKA FOREST, KENYA; A THREATENED PATCH OF THE ZANZIBAR-INHAMBANE COASTAL FOREST ECOREGION

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ABSTRACT

The Northern Zanzibar-Inhambane Coastal Forest Mosaic ecoregion, together with the Eastern Arc Montane forests, harbor densities of plant species that are among the highest in the world. These natural habitats, especially small forest patches, are highly threatened along the Kenyan coast, and only slightly less threatened in coastal Tanzania. This has resulted primarily from conversion to agricultural land, although various forms of extraction also pose significant threats. Although gazetted and protected as a national monument, the forest biodiversity is still endangered. This research focused on indigenousforest plant species of high conservation value that appear in the 2017 IUCN Red List of Threatened Species. Mapping of RedListedplant species was done by means of random walks and geo-referencing using a GPS. The entire forest maps were created using GPS coverage through systematic walking around the forest edge. The GPS readings were complemented and translated to ARC GIS 9.3 software using Google earth digitization.This research established that 27 species in 16 families are listed in the IUCN (2017) Red list of Threatened Species. 8 species are Near Threatened (NT); 14 species are Vulnerable (VU) and 5 are Endangered (EN).

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INTRODUCTION

The Northern Zanzibar-Inhambane Coastal Forest Mosaic ecoregion, together with the Eastern Arc Montane forests harbor densities of plant species that are among the highest in the world. The great diversity of habitats contributes to the species richness of the area, although the levels of species endemism, most notably among the plants, is also high in this ecoregion (Burgess and Clarke 2000).These natural habitats, especially small forest patches, are highly threatened along the Kenyan coast, and only slightly less threatened in coastal Tanzania(Burgess et al., 1998, Stattersfield et al., 1998, Burgess and Clarke 2000). This has resulted primarily from conversion to agricultural land, although various forms of extraction also pose significant threats (Githitho, 1998).In Kenya, these fragmented, sometimes in relatively miniature forest relicts conserved as 'kayas', have been earmarked as one of the 25 world's hotspots of biodiversity. To qualify as a biodiversity hotspot on Myers (2000) edition of the hotspot-map, a region must meet two strict criteria: it must contain at least 0.5% or 1,500 species of vascular plants as endemics, and it has to have lost at least 70% of its primary vegetation. One of the more remarkable features of the flora is the close relationship at the genera level with certain forests in West Africa.

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This implies an ancient forest connection and the persistence of genera that have gone extinct in between, even though relationships at the species level are not as strong (Lovett, 1993). A further feature of the endemism is the high degree of local turnover in the species between adjacent forest fragments within the landscape mosaic, and the high incidence of rare species exhibiting disjunct distributional patterns. All these features indicate an ancient history of the forests within this ecoregion, and also indicate that the species may naturally be declining in an area that has been slowly drying for millions of years (Lovett, 1993; Bullock *et al*., 1996).

International interest in the Eastern Arc Mountains and Coastal forests hotspot has increased over the last three decades as the realization of its biodiversity importance and of the global crisis affecting tropical forests has deepened (CEPF, 2005). Although descriptions of the wealth of biodiversity in the forests of the Eastern Arc Mountains date back to 1860 and there has been outstanding scientific work in the hotspot during the last 100 years, concerns for its conservation are relatively recent. Until about 30 years ago, nearly all the investment in the forests of the area had been in plantations, many of which were established after clearing indigenous forest (CEPF, 2005). Habitat restoration will increase the habitat scientific values ensuring survival of the endemic or threatened, maintenance of the unique flora as gene pools of plant germplasm and units of socio-economic development by providing herbal medicinal materials and ecotourism potential among other important

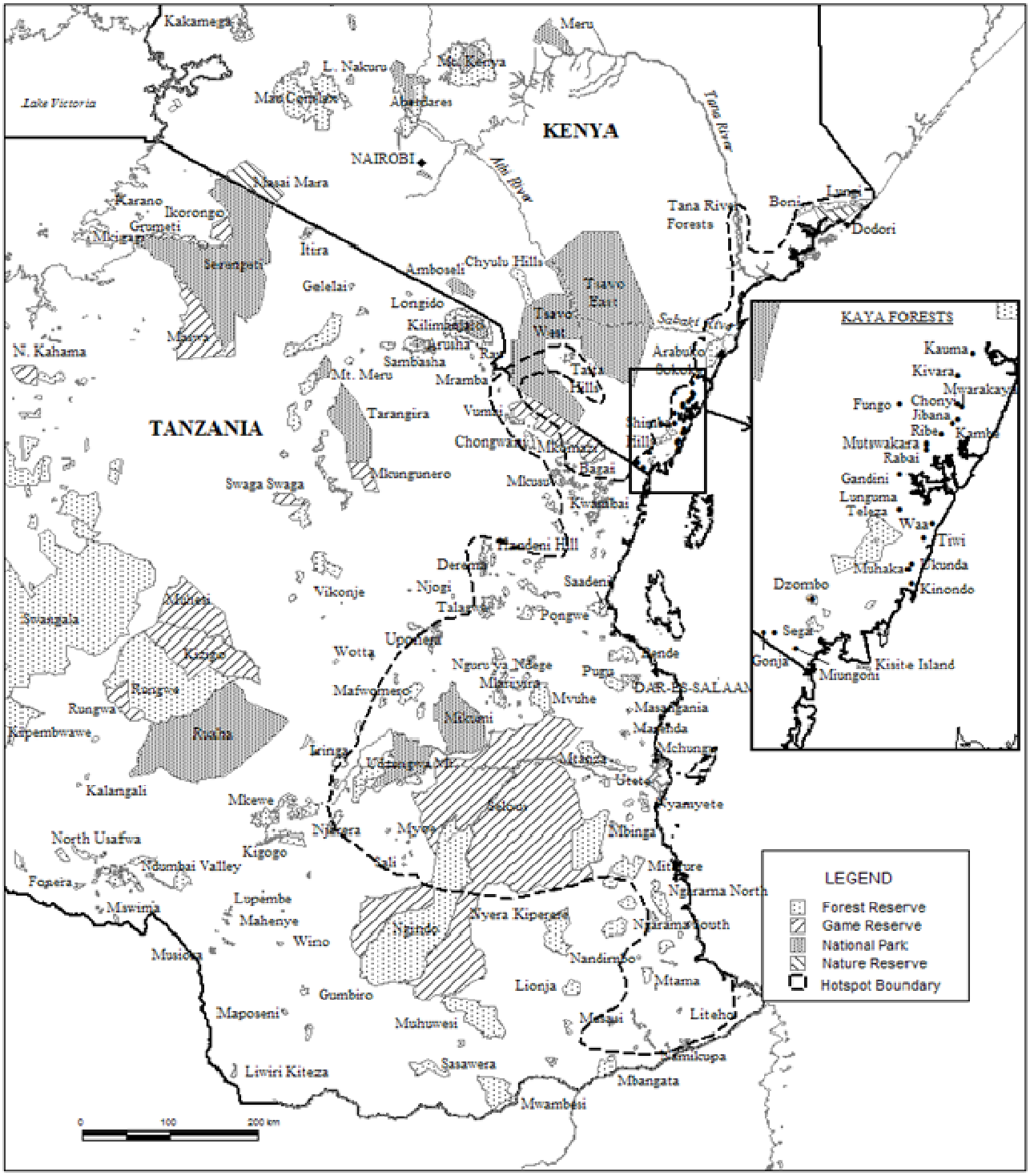


Figure 1. Map showing position of Kaya forests of the Kenyan Coast including Kaya Muhaka.

resources (UNESCO, 2009). The latest UNESCO list of Intangible Culture includes several sacred sites and sacred traditions. The Committee considered these cultural elements as endangered despite the efforts of the communities or groups concerned. Following the inscription, countries concerned will implement specific safeguarding plans, as indicated in their nomination files. The Kayas demonstrate authenticity but aspects associated with traditional practices are highly vulnerable. (UNESCO, 2009).

Research Objective

The objective of this research was to establish the presence, regeneration potential and conservation status of IUCN RedListed species that exist within the Kaya Muhaka forest, Kwale County, Kenya.

The IUCN RedList

The IUCN Red List of Threatened Species™ provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (IUCN, 2017). For the purposes of this study, the IUCN (2017) categories of interest were;

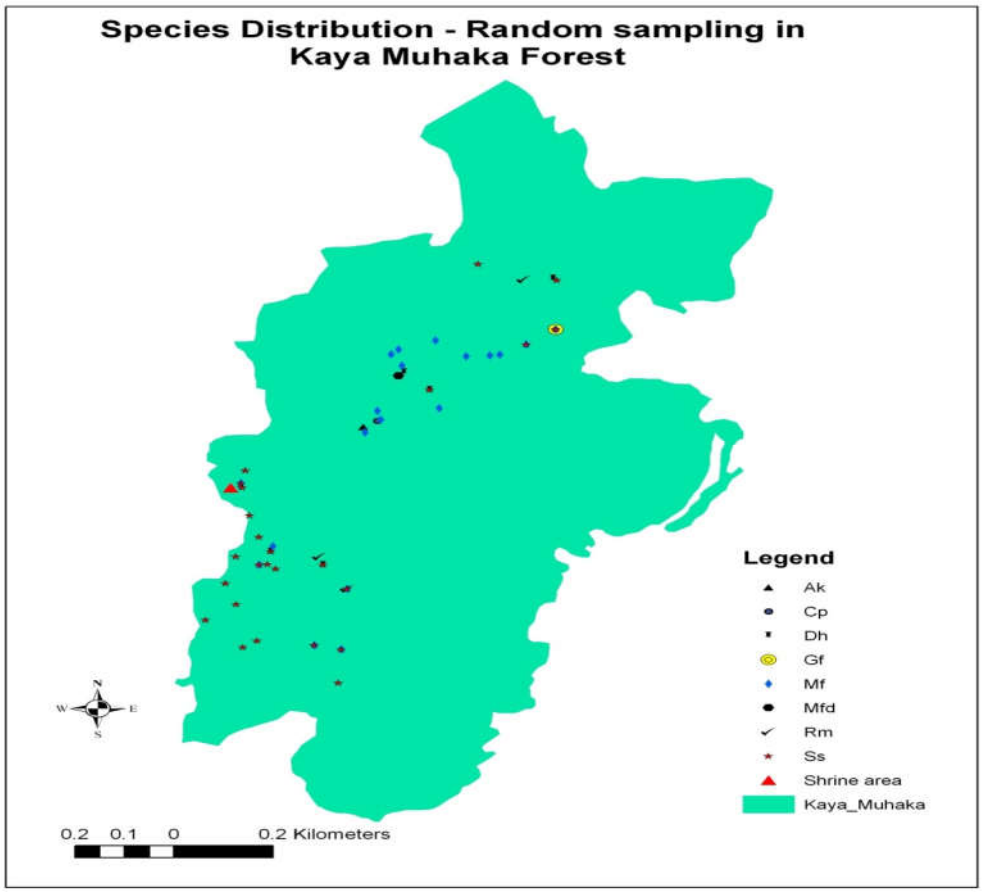


Figure 2: Random sampling points in Kaya Muhaka forest for RedListed species IUCN (2017).

Legend; Ak- *Artabotrysmodestus*Diels ssp. *macranthus*Verdc.;Cp- *Cola octoloboides* Brenan; Dh- *Dialiumholtzii* Harms; Gf- *Gigasiphonmacrosiphon* (Harms) Brenan; Mf- *Mkiluafragrans*Verdc.; Mfd- *Mkiluafragrans*Verdc. stumps; Rm- *Rothmaniamacrosiphon* (Engl.)Bridson; Ss-*Synsepalumsubverticillatum* (E.A.Bruce) T.D.Penn.

Endangered (EN), when the best available evidence indicates that a taxonfaces a very high risk of extinction in the wild;Vulnerable (VU),when the best available evidence indicates that a taxon faces a high risk of extinction in the wild and Near Threatened (NT), when the taxon has been evaluated against the criteria butdoes not qualify for Critically Endangered, Endangered or Vulnerable now, butis close to qualifying for or is likely to qualify for a threatened category in the near future.

MATERIALS AND METHODS

Study Area: Kaya Muhaka is located about 32 km south of Mombasa and 5.5 km inland from the Indian Ocean. With 150 ha, it is one of the largest Kayas in Kwale (Myers *et al*., 2000; Lehmann &Kioko, 2005). It is located in Msambweni District, 15 km south east of the Shimba Hills, close to Muhaka village (figure 1). It is also called Kaya Kambe or Mwadabara and was gazetted as a national monument in 1992. It is found near Mwabungu, Digo; 0419°S 3931°E,45m altitude, (Robertson and Luke, 1993). Kaya Muhaka has an average annual rainfall of 1129 mm with 132 mm during December to March (February is the driest month), 568 mm during the long rains, April – June, 172 mm in July and August and 257 mm during the short rains from September to November (Jaetzold& Schmidt, 1983). Kaya Muhaka is situated on lagoonal deposits and sub recent marine deposits (Kilindini sands). The soils are complex and very deep (>130m), of varying drainage condition and colour, texture and salinity. They are classified as; albic and ferralicArenosols, orthicFerralsols, gleyicLuvisols to Acrisols and sodicPlanosols; vertigleyic Luvisols and pellicVertisols, sodic phase (Michiekaet *al*., 1978). The community around comprises mainly of subsistence farmers with high poverty levels.

Distribution and Conservation Status of Endangered Species

Particular focus was placed on plant species diversity and unique species of high conservation value as elucidated in the IUCN Red List of threatened species (IUCN, 2017). Mapping of rare threatened species was done by means of random walks and geo-referencing using a GPS. The environment around these species was recorded. Random walks were also conducted around the species to establish whether there were any seedlings. The seedlings encountered were counted and recorded. The entire forest was also mapped. The maps were created using GPS coverage through systematic walks around the forest edge. The GPS readings were complemented and translated to ARC GIS 9.3 software using Google earth digitization.

RESULTS AND DISCUSSION

Forest disturbance and conservation status of IUCN RedListed plant species

This research established that 27 plant species in 16 families are listed in the IUCN (2017) RedList of Threatened Species. Their distribution within the three categories was as follows; 8

Table 1: A Checklist of RedListed species of Kaya Muhaka IUCN (2017), sourced from http://www.iucnredlist.org/ on 6th October, 2017.

FAMILY	GENUS	SPECIES	AUTHOR 1	RANK 1	SPECIES 2	AUTHOR 2	IUCN
Annonaceae	*Asteranthe*	*asterias*	(S.Moore) Engl. & Diels	ssp.	*asterias*		NT
Annonaceae	*Isolona*	*cauliflora*	Verdc.				EN
Annonaceae	*Lettowianthus*	*stellatus*	Diels				NT
Annonaceae	*Mkilua*	*fragrans*	Verdc.				VU
Annonaceae	*Ophrypetalum*	*odoratum*	Diels	ssp.	*longipedicellatum*	Verdc.	VU
Annonaceae	*Uvariodendron*	*kirkii*	Verdc.				VU
Araceae	*Gonatopus*	*marattioides*	(Peter) Bogner				EN
Burseraceae	*Commiphora*	*obovata*	Chiov.				NT
Caesalpiniaceae	*Cynometra*	*suaheliensis*	(Taub.) Baker f.				VU
Caesalpiniaceae	*Cynometra*	*webberi*	Baker f.				VU
Caesalpiniaceae	*Dialium*	*holtzii*	Harms				VU
Caesalpiniaceae	*Gigasiphon*	*macrosiphon*	(Harms) Brenan				EN
Caesalpiniaceae	*Julbernardia*	*magnistipulata*	(Harms) Troupin				VU
Connaraceae	*Ellipanthus*	*hemandradenioides*	Brenan (Pancovia?)				NT
Ebenaceae	*Diospyros*	*greenwayi*	F.White				VU
Euphorbiaceae	*Mildbraedia*	*carpinifolia*	(Pax) Hutch.				VU
Euphorbiaceae	*Pycnocoma*	*littoralis*	Pax.				VU
Flacourtiaceae	*Bivinia*	*jalbertii*	Tul.				NT
Mimosaceae	*Newtonia*	*paucijuga*	(Harms) Brenan				VU
Moraceae	*Milicia*	*excelsa*	(Welw.) C.C.Berg				NT
Papilionaceae	*Dalbergia*	*melanoxylon*	Guill. &Perr.				NT
Papilionaceae	*Erythrina*	*sacleuxii*	Hua				NT
Rubiaceae	*Rothmannia*	*macrosiphon*	Waterman,P.G.;McKey, D				VU
Rutaceae	*Zanthoxylum*	*holtzianum*	(Engl.) P.G.Waterman	ssp.	*holtzianum*		VU
Sapindaceae	*Chytranthus*	*obliquinervis*	Radlk. ex Engl.	ssp.	*longiflorus*	(Verdc.) Halle	VU
Sapotaceae	*Synsepalum*	*subverticillatum*	E.A.Bruce				EN
Sterculiaceae	*Cola*	*octoloboides?*	Brenan				EN

Table 2: Total Number of seedlings of IUCN (2017) RedListed plant species encountered

Genus	*Species 1*	Author 1		Species 2	Aithor 2	Seedlings
Julbernadia	*magnistipulata*	(Harms) Troupin				556
Ellipanthus	*hemandradenioides*	Brenan (Pancovia?)				169
Uvariodendron	*kirkii*	Verdc.				168
Cynometra	*suaheliensis?*	(Taub.) Baker f.				88
Diospyros	*greenwayi*	F.White				86
Asteranthe	*asterias*	(S.Moore) Engl. & Diels	ssp.	asterias		70
Cynometra	*webberi*	Baker f.				49
Gigasiphon	*macrosiphon*	(Harms)Brenan				7

species were Near Threatened (NT); 14 species were Vulnerable (VU) and 5 species were Endangered (EN). The CEPF (2005) report mentioned that 333 globally threatened (RedList) speciesoccur in the Eastern African Coastal Forests Mosaic hotspot, with 105 species being represented in Kenya and 307 in Tanzania. TheseRedListed flora and fauna in the hotspot are represented by 236 plant species, 29 mammal species, 28 bird species, 33 amphibian species and 7 gastropod species. Of the333 globally threatened species in the hotspot, 241 are Vulnerable, 68 are Endangered and 24are Critically Endangered (CEPF, 2005). By comparison, 11.44% of the RedListed plant species in The Eastern African Coastal Forests Mosaic hotspot were found in Kaya Muhaka. This is indeed a considerably high population in just 150 ha of Kaya Muhaka forest. Moreover, this research established that the species are in fact having a poor regeneration with only 8 of the 27 RedListed species having seedlings (Table 2). This confirms the assertions by Burgess (1998) that the coastal forests are interpreted as a 'vanishing refuge' with the endemic species gradually becoming more and more relict (and presumably extinct) due historically to climatic desiccation and more recently to human destruction.

In this research, the following 3 species were given special interest because of their rarity in the Kaya Muhaka forest.

i) ***Gigasiphon macrosiphon*** (Harms.) Brenan. Description (Beentje, 1994);

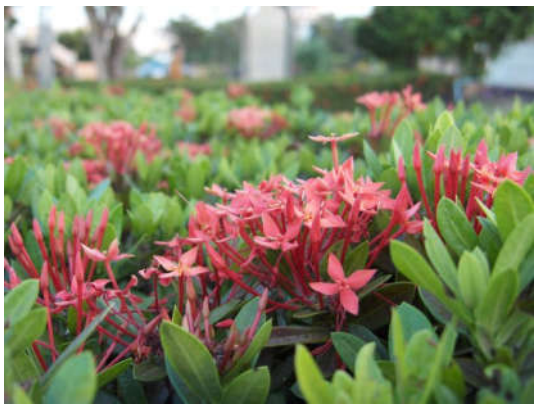
Family: *Caesalpiniaceae*; Tree 12-24m, crown rounded; bark smooth, grey. Leaves broadly ovate, base (sub-) cordate, apex acuminate, 9-20 by 7-16cm,5-veined from base, subglabrous. Flowers whiter with one (partly) yellow petal, petals 9-13 by 4-6cm. Fruits grey black, flattened 20-30 by 6-7.5cm. Habitat; K7; 100-250m altitude,in moist evergreen forest. Only known from Mrima, Gongoni, Muhaka and Marenje forests (and coastal Tanzania). Attempts by Robertson and Luke to re-find *Gigasiphon* at Mrima in 1988, during their work on the coastal forests, failed, and it was feared extinct in Kenya until they re-discovered it in Kaya Muhaka on 31 May 1990. The next day, they found another population in Gongoni Forest Reserve, where it was being logged to fuel a lime factory. They tried to relocate this species in the East Usambaras in 1998 to no avail. No repeat of Eggeling's 1951 collection of *Gigasiphon* from the Rondo Plateau in southern Tanzania was reported by Bidgood and Vollesen after their expedition to this area in February 1991(Luke &Verdcourt, 2004). Thus, by the beginning of the new century, the species was only known to exist naturally in Kaya Muhaka and Gongoni Forest Reserve, with cultivated specimens known to exist in the National Tropical Botanic Garden, Hawaii and the Botanic Garden in Nairobi. It is RedListed

Gigasiphon macrosiphon

by IUCN and classified as Endangered. It was therefore of some interest that Quentin Luke found a mature specimen in the Udzungwa Mountain NP, south-western Tanzania, on 6 October 2001, at an altitude of 880 m and that a tree planted in Quentin Luke's garden at 1800 m started flowering early in 2004, now the highest record for this potentially ornamental species. (Luke and Verdcourt, 2004).The species was found in sites where were forest gaps, presence of stumps, footpaths and evidence of firewood collection.It was found in the following geo-referenced points; 4.33845S 39.52191E,4.3384S 39.52166E and 4.33818S 39.5217E.The regeneration potential of this species was very low with a total of only 7 seedlings found in the entire forest.There were 2 populations of this species.

ii) ***Rothmannia macrosiphon*** (Engl.) Bridson.; Description (Beentje, 1994);

Family: Rubiaceae; Shrub or tree 2.5 to 8m,sometimes scrambling.Leaves somewhat obovate,base cuneate,apex acuminate,5-15 by 2-7.5 cm,glabrous or nearly so,flowers white with reddish markings, pendulous, solitary; corolla tube 135-240mm long, lobes 13-32mm long.Fruit only known in young stage, round over 30mm. Habitat;K7, 50-500m altitude in the following forests; Shimba, Buda, Marenge, Arabuko and Mangea.Economics;The fruit yields a blue black dye.It was geo-referenced at; 4.33976S 39.51955E.In the forest,this was the rarest species as it was only found at one point where there was a population of only 3 plants. The regeneration potential was zero as no seedlings were found.There was only one population of this species.IUCN (2017) categorizes it as Vulnerable. At the time of collection(Mid July, 2010) however it was



Rothmannia macrosiphon

flowering and had even produced fruits. There was evidence of firewood collection around this point which was also very close to the forest edge. The points experienced disturbance from wild pigs which dig up the soil in order to feed on seeds and create shelter.

iii) ***Colaoctoloboides*** **Brenan. Description (Beentje, 1994)**

Family: Sterculiaceae; shrub or tree 3-4m.Leaves elliptic or obovate,base obtuseor rounded,apex short- acuminate,5-21 by 2.5-8.5cm,glabrous except for the base of the midrib beneath.Flowers yellow to chocolate-brown,solitary or few,sessile and axillary,perianth tube to 7mm,lobes 14-20mm long.Mature fruit unknown.Habitat; K7, 1-450m altitude in shady crevices of forest and endemic to Cha Simba, Gongoni, Muhaka and Dzombo.Beentje (1994) classifies it as Endangered, IUCN (2017) also classifies it as Endangered (Table 1).It was found in the following geo-referenced points; 4.33334S 39.5237E, 4.33248S 39.52263E and 4.33289S 39.52199E. The regeneration potential was zero as no seedlings were found. The points experienced disturbance from wild pigs which dig up the soil in order to feed on seeds and create shelter.Footpaths and firewood collection was also evidence of disturbance. Legend; Ak- *Artabotrysmodestus*Diels ssp. *Macranthus* Verdc.;Cp- *Cola octoloboides* Brenan; Dh- *Dialiumholtzii* Harms; Gf- *Gigasiphonmacrosiphon* (Harms) Brenan; Mf- *Mkiluafragrans* Verdc.; Mfd- *Mkiluafragrans* Verdc. stumps; Rm- *Rothmaniamacrosiphon* (Engl.) Bridson; Ss- *Synsepalumsubverticillatum* (E.A.Bruce) T.D.Penn.

CONCLUSIONS AND RECOMMENDATIONS

Increase in population has led to a higher demand for wood fuel and timber for construction.The forest is highly disturbed and risks extinction if protection is not more strict and consistent. The threatened species are grossly underprotected as they are exposed to the indiscriminate logging.Therefore, the rarer tree species with poor representation in our samples need proper attention from plant biologists to determine their conservation status and key functions. Further research should be done on the conservation, presence and mapping of the endangered species in Kaya Muhaka forest. Seed collections for the IUCN RedListed species should be conducted so as to germinate and restock them in the forest.

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