Journal of East African Natural History **98**(2)**:** 223–239 (2009)

VEGETATION COMMUNITY STRUCTURE, COMPOSITION AND DISTRIBUTION PATTERN IN THE ZARANINGE FOREST, BAGAMOYO DISTRICT, TANZANIA

Cosmas Mligo, Herbet Lyaruu, Henry Ndangalasi
Department of Botany, University of Dar es Salaam
P.O. Box 35060, Dar es Salaam, Tanzania
Mligo@udsm.ac.tz, lyaruu@botany.udsm.ac.tz, hjndangalasi@udsm.ac.tz

Rob Marchant
Environment Department, University of York
Heslington, York, YO10 5DD, UK
rm524@york.ac.uk

ABSTRACT

Zaraninge Forest, part of the Coastal Forest Biodiversity Hotspot of Tanzania, is threatened by human activities. The effect of such activities on the ecology of the forest is less known. Nested quadrat sampling technique was used along pre-established transect lines. Trees had a stem density of 521 ha^{-1}, the majority falling in Diameter at Breast Height (DBH) size classes 9.5 to 44.9 cm. There was no significant difference in species diversity between sampling areas, which had a Shannon's diversity index ranging from 1.64 to 2.63. PCA identified two vegetation sample groups with *Baphia kirkii, Cynometra webberi, C. brachyrachis, Scorodophloeus fischeri* and *Tessmannia burttii* being abundant in both groups. TWINSPAN revealed three vegetation communities: Community A was fragmented woodlands characterized by the effects of fire and exploitation and having few remaining individuals of the valuable timber trees *Afzelia quanzensis* and *Pterocarpus angolensis*; community B was growing in a moist ecologically rich habitat and included rare species (*Inhambanella henriquesii*), endemic species (*T. burttii, C. brachyrachis* and *S. fischeri*); and community C had dry habitats dominated by *C. webberi* and *C. brachyrachis*. We conclude that habitat characteristics, fire, past and the present exploitation clearly influence the species diversity, distribution and variation in vegetation communities. The results are discussed in context of current and future management plans for this ecologically important forest.

Keywords: Coastal Forest of Tanzania, community structure, diversity, forest management

INTRODUCTION

Zaraninge Forest in Bagamoyo, Tanzania, is part of the wider East African Coastal Forest Ecosystem. It is one of the remnants of the once much more extensive forest coverage of the

Zanzibar-lnhambane Phytochorion vegetation zone (White, 1983; Clarke, 2000; Linder *et al.,* 2005). Zaraninge Forest is characterized by closed canopy vegetation (particularly on the plateau), woodland mosaics and thicketed scrub vegetation with dry and moist habitats. The forest at a wider scale is highly fragmented but has vegetation communities with high plant species composition, which supports a wide diversity of species of animals such as small mammals (Kiwia, 2006) and amphibians (Msuya, 1995; 2001). Although the forest is very small (about 2100 ha or 21 km^2) (Bloesch and Klötzli, 2002; 2004), existing as a fragment among the widely scattered coastal forest fragments, it is very important in conservation considerations due to high level of local forest endemic plant and animal species (Burgess & Clarke, 2000). Zaraninge forest, like many other coastal forests has been understudied. The forest has been subjected to overexploitation through logging, fuel wood collections, pole cutting and bush fire encroachment. However, little is known about the effects of such factors on the vegetation ecology of the Zaraninge Forest in terms of structure, composition change and the plant species distribution within the forest. This study therefore aimed at determining vegetation community structure, composition and plant species distribution patterns in relation to the influence of anthropogenic activities in Zaraninge Forest.

MATERIAL AND METHODS

Location of the study area

Zaraninge Forest (also known as Kiono, Kiona, Mkange or Miono) is located in Bagamoyo District, Coast region in Tanzania (Clarke & Dickinson, 1995). It is found between latitudes $6^0$4'–$6^0$13'S and longitudes $38^0$35'–$38^0$42'E (Clarke & Dickinson, 1995). It covers a plateau between 100 to 300 m rising above the Saadani coastal plain, within the Wami-River basin escarpments and surrounded by miombo woodlands and grasslands (figure 1). The forest plateau is situated on shallow soil layers covering sedimentary rocks and extends on the slopes of the western escarpment as rock outcrops. The raised plateau forms a source of small seasonal rivers draining to the Wami River and into the Indian Ocean. These seasonal rivers are the major sources of water for the surrounding villages, wildlife and pastoralists (figure 1).

Climatic conditions of Zaraninge Forest

The climate of the area is controlled by the movement of the Inter-Tropical Convergence Zone (ITCZ), between 20^0 south to north of the Equator. The convergence of air masses which brings about seasonal rainfall is manifested by the migration of the equatorial rainfall belt (Marchant *et al.*, 2006). The ITCZ is a representative of several subsystems which help in understanding the variability of local climate and the interaction with numerous other subsystems in the coastal areas such as trade wind systems. The interaction of subsystems results in seasonal displacement of ITCZ that can result in ecosystem response such as changes in composition, forms, functions, vegetation communities and the plant species distribution patterns in the coastal areas (Marchant *et al.*, 2006).

Climatic variability along coastal Tanzania greatly influences both the distribution pattern of plant species in the forests, and the composition of the forest fragments at large. The climate is monsoonal and is characterized by high temperatures and humidity in the dry and rainy seasons respectively. The average annual rainfall is below 1000 $mm.yr^{-1}$ (Clarke & Dickinson, 1995). The rainy season starts from March to June followed by relatively cool season between June and August and the short rains between September and November thus bimodal (Burgess *et al.,* 2000). The pattern of annual rainfall in the coastal forest ecosystems have drastically changed over the last ten years and has negatively impacted on plant diversity (Hall *et al.*, 2004).

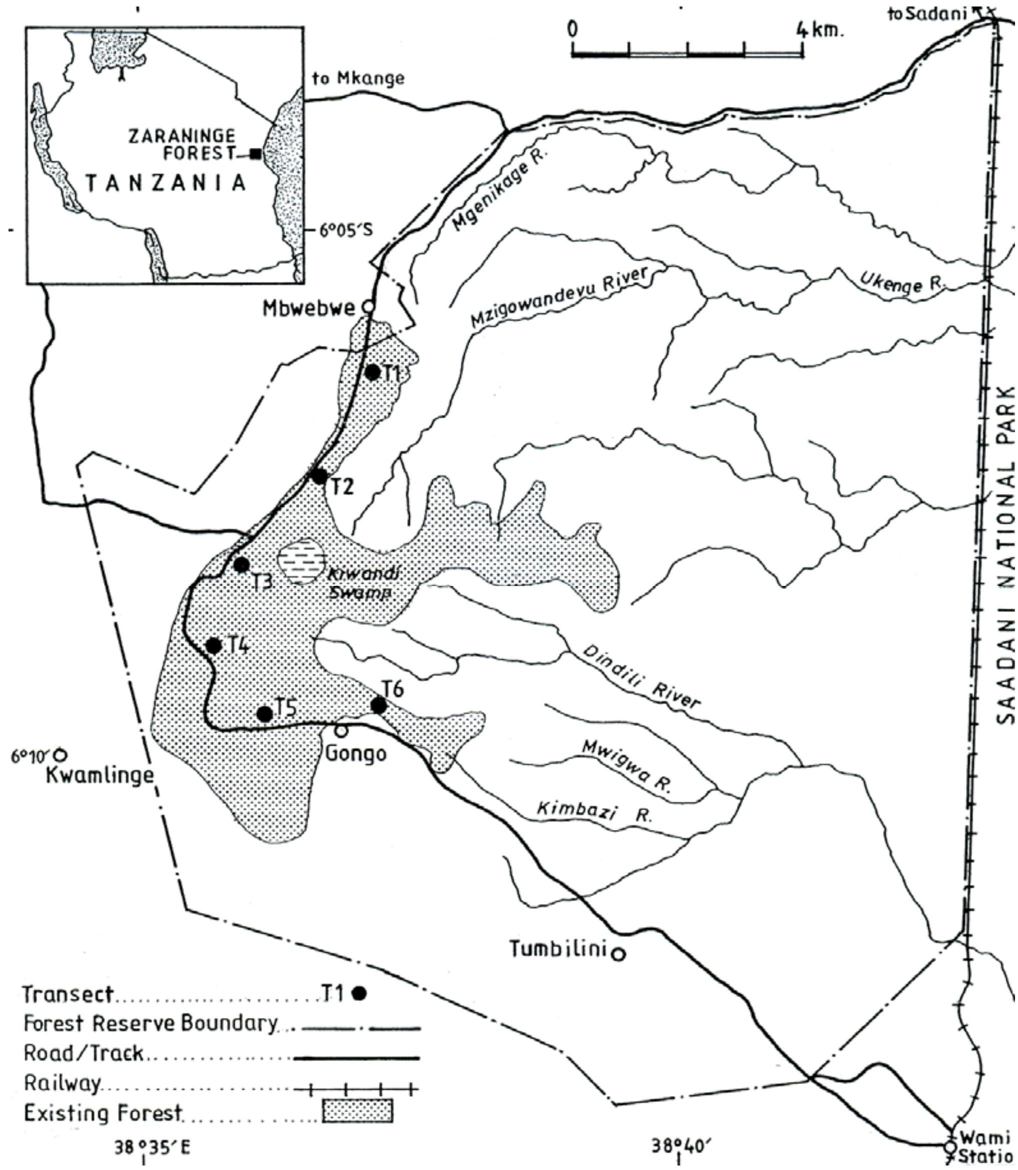

Figure 1. The map of Zaraninge Forest including the location of the transects.

Vegetation sampling

A reconnaissance survey was carried out to identify the various vegetation communities in Zaraninge Forest. There were four main vegetation communities identified in the forest which had continuities between them. Six transects of 0.65 km length each were laid out in the forest starting from the open woodlands and the permanent roads towards the inner part of the forest. Transects were laid out at intervals of 2 km apart to get a representative coverage of vegetation for subsequent data analysis. Along each transect, six nested quadrats were systematically established after every 100 m in the forest as recommended by Stohlgren *et al.* (1995). Three levels of sampling were employed in the field: (a) 25 x 20 m quadrats for trees (b) 5 x 2 m quadrats nested in the bigger quadrat for shrubs and (c) 2 x 0.5 m quadrats nested in the 5 x 2 m quadrats for herb layer, seedlings and grasses. A total of 1.8 ha of Zaraninge Forest was covered during the sampling process. Nesting of the smaller quadrats was placed at the two adjacent corners in the bigger quadrats. The information collected includes species identification, Diameter at Breast Height (DBH), total number of individuals of trees, shrubs and seedlings for plant species with the height of <30 cm. Most of the plants were identified to species level in the field when it was possible, otherwise specimens of plant species that were unidentified or unconfirmed identifications were collected, pressed and taken to the herbarium in the Department of Botany, University of Dar es Salaam (DSM) for identification or confirmation identification were done by matching with the herbarium specimens and /or keying using relevant floras such as Flora of Tropical East Africa (FTEA) and Flora Zambeziaca (FZ). For all the plant species identified in the field voucher specimens were made and deposited at DSM for future reference.

Data analysis

Vegetation data were summarized in DBH size classes. Species diversity was calculated based on Shannon and Wiener Diversity Index (Shannon, 1948). Analysis of variance was employed to compare the differences in plant species diversity between the sampling locations in Zaraninge Forest. Vegetation community analysis was done by using Two Way Indicator Species Analysis (TWINSPAN) (Noy-Meir & Whittaker, 1977). Plant species distribution pattern was assessed by using Principal Component Analysis (PCA), an indirect gradient analysis (Ter Braak, 1998). PCA was employed in the vegetation data analysis on the assumption that plant species distribution patterns and diversity are determined by environmental variables. Furthermore, PCA was used because the scale of the forest is very small and the ranges of the environmental gradients captured were so small that the response might be linear.

RESULTS

There were a total of 76 plant species in 64 genera and 26 families (appendix) identified in a 1.8 ha sample area in Zaraninge Forest, which was represented by 153 trees. The family Leguminosae had the highest species composition with 18 species of mostly trees present. The dominant tree species in this forest were *Scorodophloeus fischeri, Cynometra webberi, Cynometra brachyrachis, Brachystegia spiciformis* and *Tessmannia burttii* in the closed canopy areas of the forest, and *Afzelia quanzensis Acacia brevispica* and *Pterocarpus angolensis* in the open woodlands.

Density and DBH size class distribution

The vegetation of Zaraninge Forest was structured into clearly observable layers. The tree layer had the lowest stem density, containing 512 stems per hectare, where *Scorodophloeus fischeri* had the highest stem density comprising 35% of the total number of stems per hectare. This was then followed by *C. webberi* and *T. burtii* (which was 10% of the total number of stems/ha each). The sapling layer had about 14 472 stems.ha^{-1} with *C. webberi, Canthium mombazense, Cola clavata, Haplocoelum foliolosum* subsp. *mombasense*, *S. fischeri* and *T. burttii* being the most abundant. The seedlings in this forest were numerous (194 583.33 stems.ha^{-1}) and dominated by seedlings of *C. brachyrachis, C. webberi, H. mombazense, Manilkara sulcata, Milletia impressa* and *S. fischeri*. The DBH class size distribution shows that the majority of individuals of tree species had sizes between 9.5 and 44.9 cm. Trees with DBH sizes above 90 cm were rare and included *Brachystegia spiciformis, Cussonia zimmermannii, C. brachyrachis, Nesogordonia holtzii*, *T. burttii* and *S. fischeri* (figure 2).

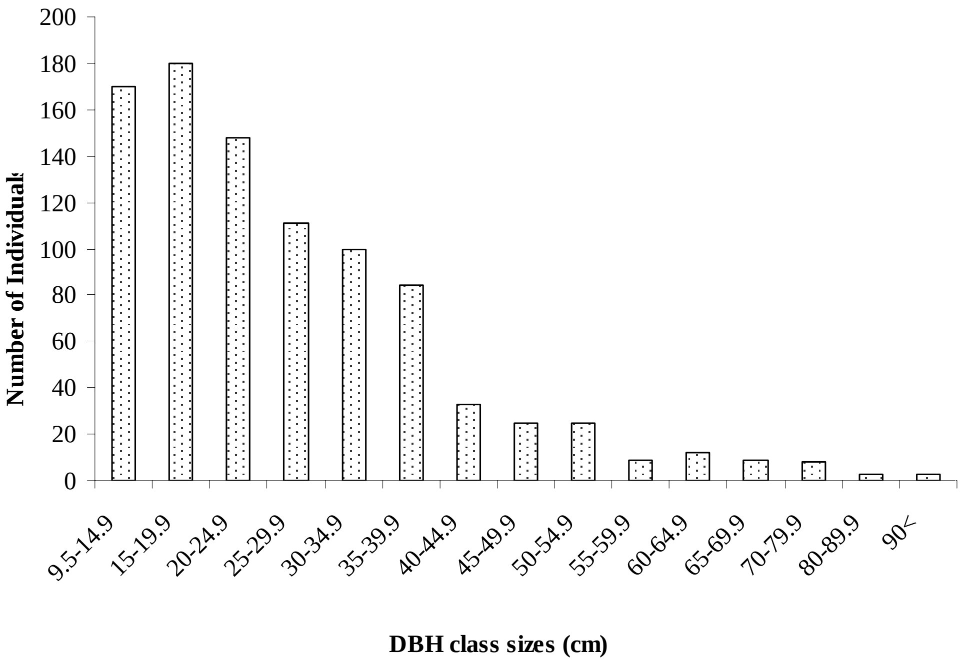

Figure 2. DBH class size distribution of trees in Zaraninge Forest.

Four tree species which area highly exploited for charcoal, timber and poles in the coastal forests were selected for further analysis of their DBH size class distribution (figure 3). *S. fischeri* showed a stable pattern of the DBH class sizes. The timber species *C. webberi* and *P. angolensis* had a bell shaped curve with a poor representation in both lower and higher DBH class sizes. This shows an interrupted population structure owing to poor recruitments of seedlings. *Afzelia quanzensis* had balanced representation in lower DBH classes but lacking in higher DBH classes. This implies that illegal harvesting is still on going in the open woodlands of Zaraninge Forest, targeting trees with DBH above 20 cm.

Species diversity

Shannon's diversity indices ranged from 1.63 to 2.69 in Zaraninge Forest. Species diversity was the highest in the first transect (T1) which was established closer to Mbwebwe village (figure 1 & figure 4). Species diversity increased with increasing distance from the forest edge, permanent roads and areas closer to the human settlements particularly Gongo village (figure 4). The plots closer to human settlements, for example Transect 6 (T6) laid near to Gongo village (figure 1), recorded the lowest species diversity. On the other hand, plant species diversity increased towards the north-eastern part of the forest. Although the species diversity was high in this area of the forest, analysis of variance showed no significant difference from one sampling point to the other within sample points in the forest plateau as well as samples of the woodlands (P > 0.05).

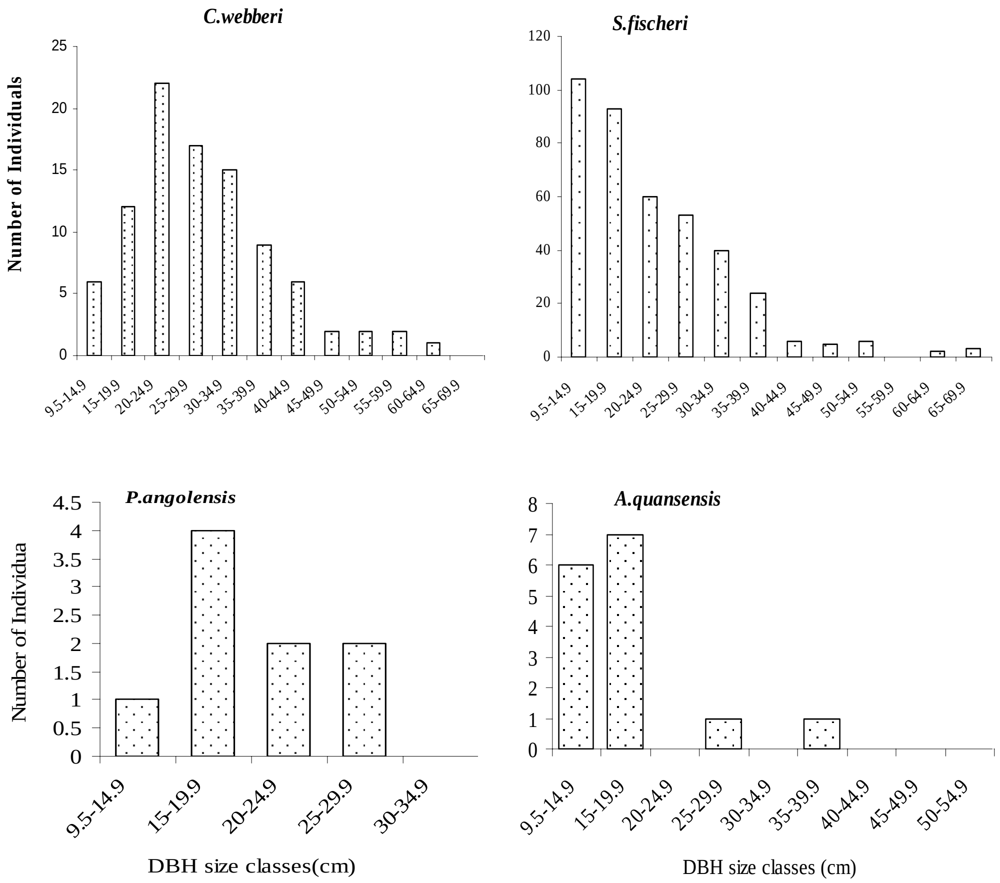

Figure 3. The DBH class size distribution of selected species S. fischeri, C. webberi, P. angolensis *and* A. quanzensis.

Classification of the vegetation of the Zaraninge Forest using TWINSPAN
Using TWINSPAN, the species recorded were clustered into three vegetation community groups labeled as A, B, and C (figure 5). The TWISPAN resulted into a dendrogram showing hierarchical separations of sampling plots on the basis of indicator species. Woodland community A represents the miombo woodland that surrounds the elevated part of the forest (Kiono Plateau). Bands of *Brachystegia spiciformis* dominated parts of Zaraninge Forest and cut across the plateau from west to the east through the middle part of the forest. The most common plant species includes *Pterocarpus angolensis* in open wooded grassland.

Afzelia quanzensis, Manilkara sulcata and *Sclerocarya birrea* are found in the thickets. Also, *Terminalia spinosa* was among species sparsely scattered in the woodlands. The transition zone of the closed canopy and open woodland was dominated by *Nesogordonia holtzii*.

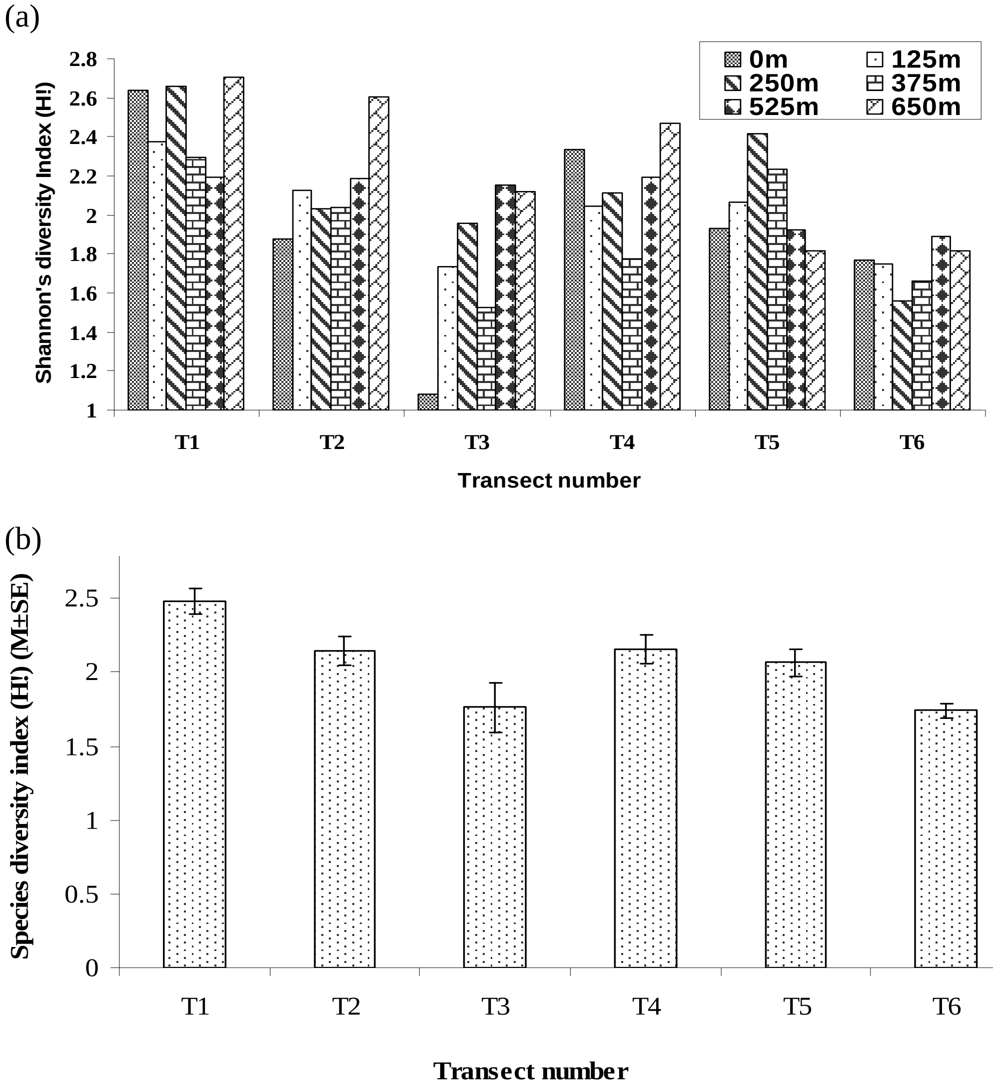

Figure 4. Variation in plant species diversity (a) with increased distance from human settlements, forest boundary and (b) among transects.

Community B was that of *Scorodophloeus-Tessmannia* dominance. *Scorodophloeus fischeri* was a widespread species in the forest dominating the Kiono Plateau and areas with minimum disturbance and moist habitat of Zaraninge Forest. The understorey layer was dominated by the saplings and seedlings of *S. fischeri* which coexisted with *Encephalartos hildebrandtii*, *Inhambanella henriquesii*, *Milletia impressa* and *Tessmannia_burttii*. This community is also characterized by the high abundance of endemic plant species such as *Cola clavata, E. hildebrandtii, Uvaria acuminata* and *Salacia madagascariensis*. Other dominant species in this community include *Baphia kirkii, Dalium holstii* with regenerants of *S. fischeri, Milletia impressa* and *Cynometra webberi* in the understorey.

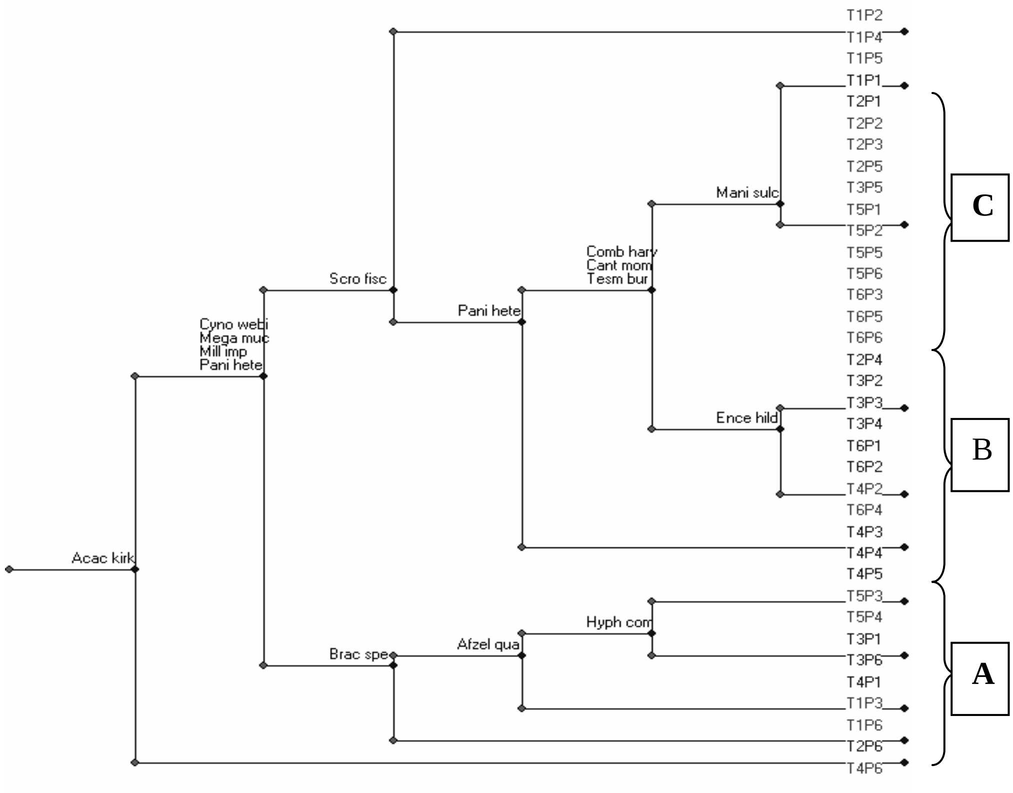

Figure 5. Dendrogram showing vegetation communities in Zaraninge Forest.

Community C was represented by a *Cynometra-Haplocoelum* dominance. This was another plant species rich community. The most abundant and dominant plant species in the community were *Brachylaena huillensis*, *Cynometra brachyrachis*, *C. webberi* and *Haplocoelum foliolosum* subsp. *mombasense*. *Salacia madagascariensis* was also well represented in this community. This community had many tree species of lower DBH size classes than elsewhere in the forest.

Plant species abundance and distribution pattern in Zaraninge Forest

Principal Component Analysis displayed grouping of plant species that helped to identify their abundance and distribution patterns in the forest (figure 6). The hypothetical environmental variables provide an explanation of the plant species abundance and distribution patterns. Sample points are scattered in the two major groups and randomly distributed in ordination space. The first group scoring low gradient at axis 1 (*i.e.* occupied lowest position on the scale values in PCA axis 1). This group of sample plots occupies the left side of the PCA ordination diagram are those that were established in the open woodland (miombo woodlands), low plains (thicketed scrub forests) up to the forest edge. The most dominant plant species were *Acacia brevispica, Afzelia quanzensis, Pterocarpus angolensis* and palms. The second group (scoring high gradient on PCA axis 1 and located on the right side of the diagram) was established in the interior part and the plateau of Zaraninge Forest which were dominated by *Baphia kirkii, Cynometra brachyrachis, C. webberi, Tessmannia burttii* and *Scorodophloeus fischeri*. The PCA ordination diagrams shows that *S. fischeri* was the most abundant tree species with the widest distribution in the forest. It dominates all habitats from the northern drier part to the southern moist part particularly the plots in the left side of the PCA ordination diagram. The next most dominant species were *Baphia kirkii, Cynometra brachyrachis, C. webberi* and *Tessmannia burttii* (figure 6).

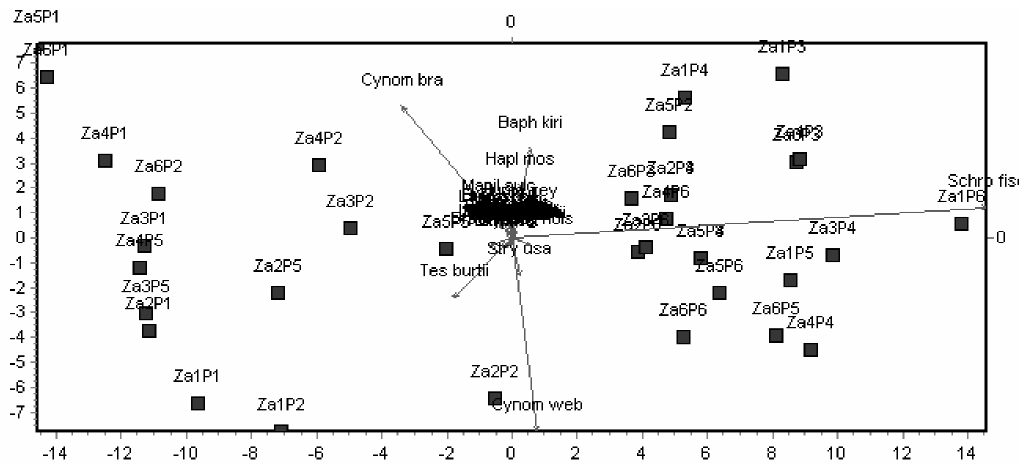

Figure 6. PCA ordination of the samples species data in Zaraninge Forest.

DISCUSSION

Population structure and density distribution

Being one of the coastal forest fragments, the ecological characteristics of Zaraninge Forest such as high stem density of forests dependent plant species are well represented. The forest community structure was representing a forest which is nearly to its pristine conditions due to high level of recovery from disturbance. As a general trend in a healthy vegetation community, the tree layer had the lowest stem density progressively with saplings and seedlings. *Scorodophloeus fischeri* had the highest stem density of followed by *Cynometra webberi* and *Tessmannia burttii*. Similarly, at the sapling and seedling layer, the densities of the same species were the most significant. Higher density of woody species in this forest might have been contributed by the decreased human pressure and hence many of the species grow luxuriantly. Mwasumbi *et al.* (1994) reported that, much of the forest parts were recovering of its habitats and ecological condition, although there were some logging and farmland encroachment. The present study observed higher stem density of trees than that reported by Clarke and Dickinson (1995). This shows a potential vegetation recovery of Zaraninge Forest. The analysis of the population structure and DBH size class distribution showed that most of the trees had low DBH size classes. This is an indication that many tree populations were previously subjected to exploitation pressure with the resultant DBH size classes being skewed to the lowest size classes. The result also shows that the population is recruiting strongly and there are signs of recovery from the effects of previous selective logging. Timber logging in the forest was one of the factors that have resulted into the present status of the forest, and still the exploitation continues although at a much lesser extent. Tree species with DBH size classes above 100 cm were rare. Although some of the tree species do not grow up to such a DBH size classes, most of the trees reported from other coastal forests of Tanzania which are suitable for logging at the DBH size classes of 100 and above were very rare. This is clearly an indicating that anthropogenic activities affected the forest in the past. Logging activities occurred intensively before the 1980s and decreased gradually through the early 1990s which might have encouraged regeneration of many of the dominant species in the forest. Illegal pit sawing was noted in the woodlands during field work indicating that degradation still continuous in the coastal forests. Likewise, there were also little dead wood materials in the forest, which may be due to termite activities as well as dead wood being collected for fuel by the villagers around the forest.

According to Argaw *et al.* (1999), a regenerating population becomes stable when there is more recruitment of individuals at lower DBH sizes class declining subsequently to higher DBH size classes. The narrow inverted J-shaped distribution curve for *Scorodophloeus fischeri* with high density of DBH at 9.5 – 39.9 cm shows that the population is expanding with very active recruitment of seedling. On the other hand, *Cynometra webberi* and *Manilkara sulcata* had bell shaped distribution patterns showing poor regeneration that might be related to regeneration failure due to selective exploitation of fertile trees leaving a few genetically impoverished individuals. Poor representation of *Afzelia quanzensis* and *Pterocarpus angolensis* which are also highly valued timber species at higher DBH classes is an indication that the plant species had been seriously logged and pit sawn previously and only a few mature individuals with DBH greater than 40 cm were seldom. Although few individual trees in the forest survived from the previous disturbance regime, currently there are active recruitments for the forest dependent tree species. It seems therefore that Zaraninge Forest is at a crucial stage of regeneration and has been recovering since suspension of logging.

Vegetation communities

The community analysis resulted in three different vegetation community types. The differentiation of the groups is due to the influence of human activities and environmental factors. Community A consisted of woodland, scrub forest and wooded grassland. It was strongly influenced by bush fires and illegal exploitation of tree species for timber, charcoal, building poles and medicinal uses. In addition, the increase in fire impact is thought to result from increasing population of pastoralists immigrating to the areas close to the Zaraninge Forest where they use the grasslands for their livestock and set fires to stimulate pasture for their cattle. The community seems to be fragmented possibly due to the effects of frequent burning of the woodlands by the pastoralist, and sometimes burning that expands from the neighbouring farms or from communal lands.

Community B found in the southern part of the forest does not appear to be highly affected by previous human activities. The community is dominated by *Scorodophloeus fischeri*, *Tessmannia burttii*, *Milletia impressa* and *Baphia kirkii* and it was relatively undisturbed. This community was also characterized by high abundance of endemic species such as *Cola clavata*, *Encephalartos hildebrandtii* and *Uvaria acuminata.* These species were very narrowly distributed or limited and localized only in the moist habitats in the forest. Such habitats provide favourable conditions for their performance and regeneration of the above mentioned endemic plant species. Similarities of vegetation community B and C was high with many common plant species. However, the major difference between them is that community B is in moist habitats and has plant species that perform best in moist habitats. It also suffered less from previous disturbance. On the other hand, community C was characterized by dry habitats dominated by *Cynometra brachyrachis, C. webberi, Brachylaena huillensis* and *Haplocoelum foliolosum* subsp. *mombasense* which are coastal endemic taxa. This community presumably was affected by previous intensive logging as depicted by majority of the tree species with lower DBH size classes than those found elsewhere in the forest. *Manilkara sulcata,* the most vulnerable tree species due to charcoal and fuel wood production in the coastal area, was sparsely distributed with low DBH size classes in community C, indicating that such a species may have been heavily exploited previously hence its sparse distribution. At present, *Manilkara sulcata* is represented by saplings with few adult individuals.

Plant species diversity in Zaraninge Forest

Species diversity is among the most important parameters for ecological assessments and recommendation for conservation that has been used in various studies in the coastal forests of Tanzania (Clarke & Dickinson, 1995; Burgess *et al.*, 2000; Ahrends, 2005). Diversity was determined in different sampling areas for assessing the ecological integrity of Zaraninge Forest. From the present analysis plant species diversity was high in transect one which was located more to the north than other transects. However, analysis of variance showed no significant difference among the sampling points ($P>0.05$). Habitat variation and the effects of human activities were among the factors that contributed much to the observed variation in plant species diversity. It was found that the first plot where the transect starts (forest boundaries and areas of human settlements) records the lowest species diversity with diversity increasing towards the interior and away moving northwards from the human settlements. Although the southern part of the Zaraninge Forest closer to Gongo village was characterised by moist habitats and favourable for active regeneration of forest dependent plant species, human disturbance affected the community and resulted into the lowest species diversity for the transect established in this area (T6). Some of the tree species have been exploited and encroachment through cultivation on the forest edges that contributed to decreased species diversity close to human settlements (T6). This pattern of effects in plant species diversity might have been due to clearing of the forest edges for cultivation, fuel wood harvesting and pole cutting for settlement construction since majority of houses in Gongo village are built from wood materials. Diversity increased towards the north-eastern part of the forest from transect six (T6), implying the effect of human activities in the forest parts closer to settlements where encroachment of the pristine forest edges due to pineapple (*Ananas comosus* (L.) Merr) cultivation is taking place continuously. Likewise, areas of the forest closer to Gongo village have been exploited for poles for building fence to prevent monkeys from destroying *A. comosus* fruits in the farms. On the other hand, plant species diversity in transect 3 (T3) was low because of the dominance of few trees, *e.g. Scorodophloeus fischeri.* Regardless of the favourable habitats, the closed canopy could not support recruitment of other plant species, which resulted in a pure stand in the area towards Kiwandi swamp. Also, there was high abundance of a few woody species along T4 (figure 1) dominated by *Brachystegia spiciformis*, forming a belt of miombo woodland running from the woodlands and grasslands across the middle part of the forest to the Dindili River catchment. The woodlands and grasslands are frequently subjected to fierce burning during the dry seasons leaving only a few fire tolerant plant species. In this part of the forest, there was evidence of very recent pit sawing activity, showing that there is still illegal exploitation of tree species. .*Afzelia quanzensis* and *Pterocarpus angolensis* were among the valued timber species that are harvested in the open woodlands in Zaraninge Forest. Illegal exploitation still continues regardless of the current management that has been undertaken by Tanzania National Park (TANAPA) authority. Possibly intensive protection of the forest is concentrated on the Kiono Plateau leaving the open woodlands vulnerable for illegal harvesting and burning.

Plant species distribution patterns in the forest

Plant species distribution pattern in Zaraninge Forest is influenced by habitat conditions and human activities. Selective exploitation of some plant species contributed to the uneven distribution of specific plant species in the area. Many species with higher timber value suffered from the previous episodes of logging and some of them are seldom found in the forest. For example, a few individuals of species such as *Pterocarpus angolensis* and *Afzelia quanzensis* in the miombo woodlands may indicate that these species were previously abundant in the area and widely distributed, but are now restricted due to exploitation. The small population of *P. angolensis* and *A. quanzensis* in the miombo woodlands may also be due to unfavourable habitat conditions in the coastal areas that might have been contributed by disturbance. Moomaw (1960) noted that *Brachystegia spiciformis* was part of open woodlands in the coastal forests of Kenya. The dominance of such a tree species was due to the consequence of previously anthropogenic disturbances exploiting many valuable timber species. The uncommon nature of these taxa is probably due to infertility of the soil and moisture shortage in the coastal areas. According to Janzen (1974), miombo woodland grows in pure white and very infertile sand soils. He further noted that tropical forests growing in purely infertile sands had extremely poor regeneration. On the other hand, low density of *P. angolensis* and *A. quanzensis* species of ecological conservation value consideration and of high significance to the ecology of the miombo woodland in parts of Zaraninge Forest might be contributed by exploitation and fire effects. Hawthorne (1984) noted that *A. quanzensis, Baphia kirkii, Erythrina sacleuxii* and *Pteleopsis myrtifolia* were localized close to the forest edge whereas *Scorodophloeus fischeri* was located on the steep slopes. However, the present study contradicts these finding with *A. quanzensis* widely distributed from the forest edges to the open woodlands and the scrublands. *B. kirkii, E. sacleuxii* and *P. myrtifolia* were found in moist habitats where they co-existed with rare and endemic species. Moreover, *S. fischeri* was widely distributed on the ridge tops and the Zaraninge Forest plateau, but not on the steep slopes as has been reported in the previous studies. This pattern has also been observed in Pande Forest where the steep slopes, areas with maximum sunlight illumination were dominated by *Manilkara sulcata* whereas the plateaus were dominated by *S. fischeri*. Thus, the present study indicates that the distribution of plant species in the coastal forests is quite specific and depends upon a combination of variation in habitat conditions, ecological interactions and past the present human impacts.

Management implications

Ownership changes in conservation and management of Zaraninge Forest, from local community to wildlife division and finally the Saadani National Park (SANAPA), might have eased the pressure on forest resources and reduced encroachment. The agreement by the above institutions to share efforts in conserving the forest and involve community participation has tremendously reduced the forest degradation. It appears that participatory forest management as has been reported by Blomely *et al* (2008) is the strongest technique for biodiversity conservation in coastal forests of Tanzania. There is still access of the neighbouring communities for forest resources such as building poles and other materials. Additional threats to the forest included establishment of tourist paths in the forest, collection of medicinal plants and increased fire frequency.

There are currently no indigenous plant species grown in the community land for future use, a situation that will make the conservation efforts on the forest more difficult in the future. Although there has been an attempt to establish artificial forests to compensate for resource needs from the forest, this has not been successful due to lack of skills to implement agroforestry practices. The study has found sufficient amount of propagules of indigenous plant species in the forest that can be used to re-establish new agroforests in the villages surrounding the area Zaraninge Forest. However, there are no agroforestry technical services and thus no motivation among the villagers that could help them establish agroforests based on indigenous plant species.

Agricultural land use is limited to the people from villages around the forest edges such as Gongo and Mbwebwe where pristine forest parts continue to be encroached. There has been a gradual increase in cultivation of pineapples for external market purposes. This has expanded significantly in recent years and the population of subsistence farmers is increasing as there is good access to markets. The natural forest products and cultivation of pineapples are the means of earning income and hence highly practiced in the area at the expense of clearing the pristine zone of the forest. Although there are newly established boundaries between forest patches managed by the community and those under TANAPA, with the increase pineapple cultivation, clearance of pristine land in the community forest patches is expected to increase and Zaraninge forest's survival will be threatened.

CONCLUSION

Dominant plant species in Zaraninge Forest have been studied at all levels from seedlings, saplings, shrubs and trees. The tree layer is characterized by low DBH size classes with a few individuals represented by the higher DBH size classes. Selective exploitation on mature tree species in the forest and logging that occurred before 1980's have affected the structure, composition and distribution pattern of plant species in Zaraninge Forest. The current level of diversity and richness shows that the forest is at a recovery stage from previous disturbances in the plateau with plant species that can recover easily from fires dominating the miombo woodland. It can be recommended that to safeguard the future of Zaraninge Forest which has reasonably favourable habitat conditions with a great number of endemic plant species, the human threats to the forest need to be minimized and or inhibited. This can be done through a possible option of enforcing the establishment of community forests by using native plant species of high timber value and those suitable for poles and or material for settlement construction in the community lands. Fire lanes should be broadened in the forest boundaries so as to prevent bush fires emanating from the community lands or fire which can be initiated by hunters and honey gatherers in the forest surrounding areas. Also the population of Barabaig and Maasai pastoralists immigrating to the coastal areas that are inhabiting the community rangelands and Zaraninge grassy habitats needs to be controlled to avoid overgrazing and subsequent forest degradation.

ACKNOWLEDGMENTS

SIDA/SAREC is thanked for the support through postgraduate research funds and CEPF postgraduate research grants which helped to carry out the fieldwork. We highly acknowledge TANAPA headquarters and the warden for Saadani National Park for granting us unconditional permission to enter and work in Zaraninge Forests. Rob Marchant acknowledges support from Marie-Curie award MC-EXT-519703 for support. We extend gratitude to various participants including Mr. Suleiman (botanist), K. Kibwigiri and H. Mhagama (drivers), M. Mataula and A. Meremeta (casual labourers) and the Faculty of Science, University of Dar es salaam for allowing us to hire a vehicle for fieldwork.

REFERENCES

Ahrends, A. (2005). Patterns of Degradation in Lowland Coastal Forests in Tanzania. Unpublished MSc. Thesis, University of Greifswald, Germany.

Argaw, M., D. Teketay & M. Olsson (1999). Soil seed flora, germination and regeneration pattern of woody species in an *Acacia* woodland of Rift Valley in Ethiopia. *Journal of Arid Environments* **43**: 411–435.

Bloesch, U. & F. Klötzli (2004). *Coastal Forests of the Saadani National Park; Conservation Values and Management*. Wildlife Discussion Paper No. 37. Wildlife Division in Tanzania Ministry of Natural Resources & Tourism, Dar es Salaam.

Blomley, T., K. Pfliegner, J. Isango, E. Zahabu, A. Ahrends & N. Burgess (2008). Seeing the wood for trees: an assessment of the impact of participatory forest management on forest conditions in Tanzania. *Oryx* **42**(3): 380–391.

Burgess, N.D. & G. P. Clarke (eds.) (2000). *Coastal Forest of Eastern Africa*. IUCN Gland and Cambridge, U.K. P. 443.

Burgess, N.D., G.P. Clarke, J. Madgewick, S.A. Robertson & A. Dickinson (2000). Distribution and status. In. N.D. Burgess & G.P. Clarke (eds), *The Coastal Forests of Eastern Africa*. IUCN Gland and Cambridge, U.K. Pp. 71–81.

Clarke, G.P. (2000). Climate and climatic history. In N.D. Burgess & G.P. Clarke (eds.), *Coastal Forests of Eastern Africa*. IUCN, Gland and Cambridge, U.K. Pp. 47–67.

Clarke, G.P. & A. Dickinson (1995). *Status Report for 11 Coastal Forests in the Coast Region of Tanzania*. Frontier-Tanzania Technical Report No.17. The Society for Environmental Exploration, UK / University of Dar es Salaam.

Hall S.M., S. Standdon, K.M. Howell & E. Fanning (eds) (2004). *Kazimzumbwi Forest Reserve. A biodiversity survey*. Frontier Report 110, Frontier Tanzania, Dar es salaam.

Hawthorne, W.J. (1984). Biogeographic and Ecological Patterns in the Coastal Forests of Kenya and Tanzania. PhD thesis, University of Oxford, UK.

Janzen, D. (1974). Tropical black water river animals and mast fruiting by the Dipterocarpaceae. *Biotropica* **6**: 69–103.

Kiwia, H.Y.D. (2006). Species richness and abundance estimates of small mammals in Zaraninge coastal forest in Tanzania. *Tanzania Journal of Science* **32**(2):105–116.

Linder, H.P., J.C. Lovett, J. Mutke, W. Barthlott, N. Jürgens, T. Reblo & W. Küper (2005). A numerical re-evaluation of the sub-Saharan Phytochoria of mainland Africa. *Biologiske Skrifter* **55**: 229–252.

Marchant, R., C. Mumbi, S. Behera & T. Yamagata (2006). The Indian Ocean dipole—the unsung driver of climatic variability in East Africa. *African Journal of Ecology* **45**: 4–16.

Moomaw, J.C. (1960). *A Study of Plant Ecology of Coastal Region of Kenya* A *study of the plant ecology of the Coast region of Kenya colony, British East Africa*. Government Printer,. Nairobi.

Mwasumbi, L.B., N.D. Burgess, & G.P. Clarke (1994). Vegetation of Pande and Kiono, Coastal forests. Tanzania. *Vegetatio* **113**: 71-81.

Msuya, C.A. (1995). Checklist and Distribution of the Frog Fauna of Zaraninge Forest Reserve, Bagamoyo District. In Howell, K.M., Mturi, F.A. and Urasa, F.M. (eds), *Proceedings Coastal Forest Biodiversity Workshop*. University of Dar es Salaam. Pp. 138–141.

Msuya, C.A. (2001). Habitats, Distribution and Feeding of Amphibians in Zaraninge Forest Reserve, Tanzania. Unpublished PhD. Thesis, University of Dar es Salaam.

Noy-Meir, I. & R.H. Whittaker (1977). Continuous multivariate methods in community analysis; Some problems and developments. *Vegetatio* **74**: 9–32.

Shanon, C.F. & W. Weaver (1948). The Mathematical Theory of Communication. University of Illinois Press, Urbana:

Stohlgren, T.J., M.B. Falkner & L.D. Schell (1995). A Modified-Whittaker nested vegetation sampling method. *Vegetatio* : 113–121.

Ter-Braak, C.J.F. (2005). Analysis of vegetation environmental relationships by canonical correspondence analysis. *Vegetatio* **69**: 69–77.

White, F. (1983). *The Vegetation of Africa: a Descriptive Memoir to accompany the UNESCO/AETFAT/UNSO Vegetation Map of Africa*. Natural Resources Research XX, Unesco, Paris.

Appendix. Checklist of plant species identified in Zaraninge Forest Reserve. S= shrub; T= tree; Cl = climber; H = herb; MC= Mligo Cosmas, HS = Haji Suleiman

Family	Name	Life form	Collectors number
ANACARDIACEAE	*Lannea schweinfurthii* (Engl.) Engl.	T	MC & HS 1
	Rhus natalensis Bernh. ex C.Krauss	S	MC & HS 12
	Sclerocarya birrea Hochst. subsp. *multifoliolata* (Engl.) Kokwaro	T	MC & HS 3
ANNONACEAE	*Annona senegalensis* Pers.	S	MC & HS 4
	Artabotrys modestus Diels	S	MC & HS 5
	Monodora minor Engl. & Diels	S	MC & HS 77
	Uvaria acuminata Oliv.	S	MC & HS 8
	Xylopia arenaria Engl.	T	MC & HS 6
	Xylopia mwasumbii D.M.Johnson	T	MC & HS 7
APOCYNACEAE	*Carissa edulis* (Forssk.) Vahl	CL	MC & HS 13
	Holarrhena pubescens (Buch.-Ham.) Wall. ex G.Don	S	MC & HS 9
	Hunteria zeylanica (Retz.) Gardner ex Thwaites var. *africana* (K.Schum.) Pichon	T	MC & HS 10
	Landolphia buchananii (Hallier f.) Stapf	CL	MC & HS 11
	Landolphia kirkii R.A.Dyer	CL	MC & HS 12
	Secamone parvifolia (Oliv.) Bullock	H	MC & HS 16
ARALIACEAE	*Cussonia arborea* Hochst. ex A.Rich	T	MC & HS 14
	Cussonia zimmermannii Harms	T	MC & HS 15
ASPARAGACEAE	*Asparagus africanus* Lam.	CL	MC & HS 17
	Asparagus falcatus L.	CL	
BOMBACEAE	*Bombax rhodognaphalon* K.Schum.	T	MC & HS 18
BURSERACEAE	*Commiphora zimmermannii* Engl.	T	MC & HS 19
CELASTRACEAE	*Elaeodendron buchananii* (Loes.) Loes.	T	MC & HS 33
	Maytenus undata (Thunb.) Blakelock	S	MC & HS 37
	Salacia madagascariensis (Lam.) DC.	CL	MC & HS 34
COMBRETACEAE	*Combretum harrisii* Wickens	S	MC & HS 31
	Pteleopsis myrtifolia (M.A.Lawson) Engl. & Diels	T	MC & HS 32
	Terminalia spinosa Engl.	T	MC & HS 29
COMPOSITAE	*Brachylaena huillensis* O.Hoffm.	T	MC & HS 30
CYCADACEAE	*Encephalartos hildebrandtii* A.Braun & C.D.Bouché	T	MC & HS 39
CYPERACEAE	*Scleria foliosa* Hochst.ex. A.Rich	H	MC & HS 40
EBENACEAE	*Diospyros shimbaensis* F.White	S	MC & HS 41
	Diospyros verrucosa Hiern	S	MC & HS 42
EUPHORBIACEAE	*Alchornea laxiflora* (Benth.) Pax & K.Hoffm.	S	MC & HS 43
	Bridelia cathartica G.Bertol.	S	MC & HS 44
	Croton sylvaticus Hochst.	T	MC & HS 45
	Drypetes arguta (Müll.Arg.) Hutch.	T	MC & HS 46
	Drypetes natalensis (Harv.) Hutch.	T	MC & HS 47
FLACOURTIACEAE	*Flacourtia indica* (Burm.f.) Merrill	T	MC & HS 48

Family	Name	Life form	Collectors number
GRAMINEAE	*Megastachya mucronata* (Poir.) P.Beauv.	H	MC & HS 49
	Panicum heterostachyum Hack.	H	MC & HS 50
	Panicum trichocladum Hack. ex K.Schum.	H	MC & HS 51
LEGUMINOSAE	*Acacia brevispica* Harms	CL	MC & HS 63
	Afzelia quanzensis Welw.	T	MC & HS 20
	Albizia gummifera (J.F.Gmel.) C.A.Sm.	T	MC & HS 62
	Baphia kirkii Baker	T	MC & HS 61
	Brachystegia spiciformis Benth.	T	MC & HS 28
	Cynometra brachyrachis Harms	T	MC & HS 21
	Cynometra suaheliensis Baker f.	T	MC & HS 22
	Cynometra webberi Baker f.	T	MC & HS 23
	Dalbergia melanoxylon Guill. & Perr.	T	MC & HS 65
	Dialium holtzii Harms	T	MC & HS 24
	Dichrostachys cinerea (L.) Wight & Arn.	S	MC & HS 58
	Erythrina sacleuxii Hua	T	MC & HS 57
	Hymenaea verrucosa Gaertn.	T	MC & HS 27
	Millettia impressa Harms subsp. *goetzeana* (Harms) J.B.Gillett	CL	MC & HS 64
	Piliostigma thonningii (Schumach.) Milne-Redh.	T	MC & HS 25
	Scorodophloeus fischeri (Taub.) J.Léonard	T	MC & HS 26
	Stuhlmannia moavi Taub.	T	MC & HS 29
	Tessmannia burttii Harms	T	MC & HS 38
LINACEAE	*Hugonia castaneifolia* Engl.	L	MC & HS 53
LOGANIACEAE	*Strychnos madagascariensis* Poir.	T	MC & HS 54
	Strychnos panganensis Gilg.	S	MC & HS 55
	Strychnos usambarensis Gilg.	S	MC & HS 56
OCHNACEAE	*Ochna holstii* Engl.	T	MC & HS 60
RUBIACEAE	*Canthium mombazense* Baill.	T	MC & HS 66
	Rothmannia fischeri (K.Schum.) Bullock	T	MC & HS 67
RUTACEAE	*Teclea nobilis* Delile	S	MC & HS 68
SAPINDACEAE	*Haplocoelum foliolosum (hiern) Bullock* subsp*. mombasense* (Bullock) Verdc.	T	MC & HS 69
SAPOTACEAE	*Inhambanella henriquesii* (Engl. & Warb.) Dubard	T	MC & HS 70
	Manilkara sulcata (Engl.) Dubard	T	MC & HS 71
	Mimusops fruticosa Bojer ex A.DC.	T	MC & HS 72
STERCULIACEAE	*Cola clavata* Mast.	S	MC & HS 73
	Cola microcarpa Brenan	S	MC & HS 74
	Nesogordonia holtzii (Engl.) Capuron ex L.C.Barnett & Dorr	S	MC & HS 78
	Sterculia africana (Lour.) Fiori	S	MC & HS 75
TILLIACEAE	*Grewia forbesii* Harv. ex Mast.	S	MC & HS 76