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Floristic Composition and Diversity in a Restored Community-Based Forest, Otun Ekiti, Ekiti State, Nigeria

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ABSTRACT

Community based forest conservation is a management approach that combines local traditional knowledge with modern scientific techniques in order to increase biological diversity. This study assessed the floristic composition and tree species diversity in a herbal heritage forest that was protected 20 years ago after degradation. Using a systematic line transect sampling method, two transects were laid and six sample plots (50m × 50m) were used to survey the plant species in the forest. Data collected were analyzed using descriptive statistics and plant diversity indices. A total of 100 plant species in 44 families were identified (43 trees, 19 shrubs, 18 herbs and 20 climbers). Albizia zygia was the most dominant tree species, while Euphorbiaceae was the most abundant family. Similarly, Olax subscorpioidea, Acanthus montanus, and Smilax kraussiana were the most abundant shrubs, herbs and climbers in the forest. Trees had a Shannon Weiner Index of 3.22, shrubs had 2.22, and herbs had 2.34, while climbers had 2.62. The tree species were distributed across all diameter classes, but most of them were in the regeneration phase. The forest had recovered to a large extent with the structure gradually approaching climax. This community-based forest continues to serve the multipurpose function of meeting the community's medicinal and non - timber forest product needs, while conserving endangered plant species.

Key words: biological diversity, conservation, diameter distribution, endangered species, Herbal heritage

INTRODUCTION

Plant conservation is crucial in natural resource conservation because it has a multiplier effect on natural ecological systems. The diversity of plant species is essential for human survival, economic wellbeing as well as ecosystem functioning and stability. It is an indicator of the conservation status of forest ecosystems (Schnitzler *et al*., 2008; Singh, 2002). This is important because less disturbed vegetation is capable of harbouring varieties of wildlife, regulating water flow and maintaining soil quality. However, increasing human population, fragmentation of natural habitats and over exploitation of forest plant resources among many other drivers are resulting in loss of plant diversity in natural forests. The change in land use because of the expansion of human settlements, agricultural practices and infrastructural development continue to reduce species diversity (Spies and Turner, 1999). Information on floristic composition and species distribution in these degraded forests are scarce and this presents a challenge to the success of forest restoration programmes (Addo-Fordjour *et al*. 2009; Olajuyigbe and Adaja *al.*, 2014). Understanding plant community composition and distribution patterns in a conserved area provide key information for effective management (Lovett *et al*., 2000). Hence, the concept of identifying areas with high biodiversity in conserved areas has been used as criteria for biodiversity conservation priority setting and sustainable management (Breshears *et al*., 2005).

Community based forest conservation is a strategy that achieves the management of protected areas through the use of local traditional knowledge alongside modern scientific knowledge. It is a system where local groups or communities organize themselves with varying degrees of outside support to apply their skills and knowledge to managing natural resources and environment while satisfying livelihood needs. The system thrives on the fact that long term conservation provides benefit for the local communities in terms of indigenous rights, health benefits and poverty eradication (Brosius *et al*., 1998). One of such community-based conservation projects is the Community Herbal Heritage Forest (CHHF) in Otun Ekiti, Ekiti State, Nigeria. This is a 10-hectare forest with rich vegetal resources of medicinal value and economic importance to the local people (Bankole, 1998). The Centre was protected 20 years ago, when logging and all forms of exploitation were prohibited except for the collection of non-timber

forest products and herbs through a regulated community management structure. The assessment of the flora diversity is necessary to understand the present status and level of recovery of the plants in the CHHF (Bankole, 1998; Kayode, 2006). Therefore, this study examined the plant species diversity in the community-based forest after 20 years of protection.

MATERIALS AND METHODS

Study Area

The CHHF is located in Otun Ekiti, Moba Local Government Area, Ekiti State, Nigeria. Otun Ekiti is a peri-urban settlement that lies within latitudes 7° 55' N and 8° 00' N and longitudes 5° 12' E and 5° 22' E. It is a nodal town which shares boundaries with Kwara State to the north and Osun State to the west (Figure 1). The area falls within the basement complex of south western Nigeria with isolated hills and inselbergs surrounding the town at elevations between 300 to 450 m (Adekoya *et al.*, 2003). Both dry (November - March) and wet (April-October) seasons are experienced in the area with the temperature ranging from 21°C to 28°C and high relative humidity.

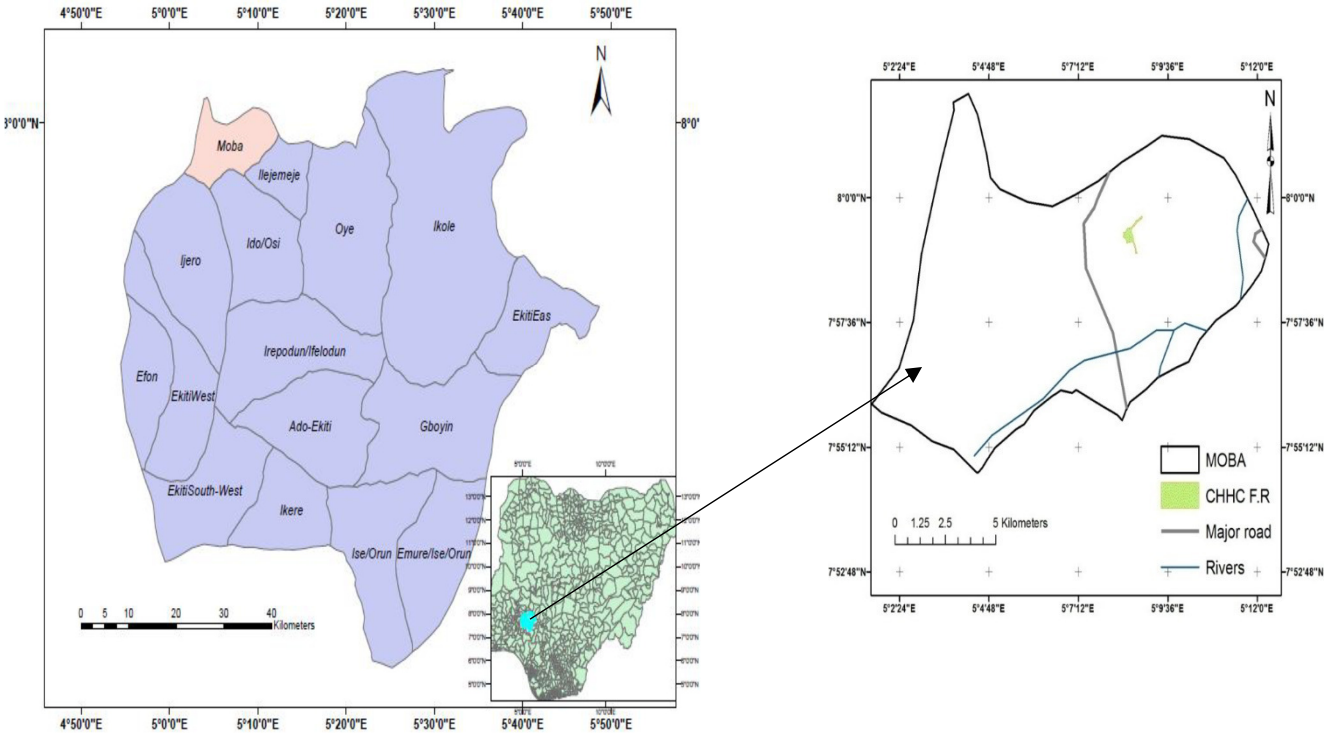

Figure 1: Map of Community Herbal Heritage Forest in Otun Ekiti, Ekiti State (inset: Map of Nigeria)

Sampling procedure

A systematic random sampling technique was used to lay six sample plots (50m by 50m each) in the 10 ha forest. A 15m offset was measured from the edge of the forest inwards and then two transects (265m in length with a distance of 200m apart) were laid in the forest. The 6 sample plots were laid in alternate positions along each transect at 50m intervals. All trees, shrubs, herbs and climbers within the plot were identified and enumerated. The diameter at breast height of trees within the plots was measured. Trees were categorized into their families and number of species in each family was determined for tree species diversity classification. Frequency of occurrence was obtained for species richness.

The number of tree species in each family was used to determine tree species diversity classification. The relative density, relative dominance, relative frequency and Important Value Index (IVI) were determined using equations 1. 2, 3 and 4 while Shannon Weiner Diversity Index (H^I), Margalef Index and species evenness were calculated using eqn. 5, 6 and 7.

Species Relative Density (RD):

$$RD = \left[\frac{n_i}{N}\right] \times 100\% \quad (1)$$

Where n_i = number of individuals of species i, and N = total number of individuals in the entire sampled population.

Relative Dominance (RD_o):

$$RD_O = \frac{(BA_i \times 100\%)}{\sum BA_n} \quad (2)$$

Where BA_i = Basal Area of all individual trees belonging to a particular species i and BA_n = Stand Basal Area.

Relative Frequency (RF):

$$R = \frac{F_i}{F_n} \times 100\% \quad (3)$$

Where F_i = Frequency of species i encountered, and F_n = Total frequency of all species.

The Important Value Index (I.V.I)

$$IVI = RD + RD_o + RF \quad (4)$$

Where RD = Relative Density, RD_o = Relative Dominance, and RF = Relative Frequency which was calculated as follows:

Shannon-Wiener diversity index

(H[1]) $$H^1 = \sum_{i=1}^{S} p_i Lnp_i \quad (5)$$

Where S = the total number of species in the secondary forest, p_i = the proportion of a species to the total number of plants in the forest, and Ln = the natural logarithm.

Species richness was calculated using Margalef Index (d)

$$d = \frac{S-1}{Ln(N)} \quad (6)$$

Where S = Total number of species N = Total number of individuals of all species

Species evenness (Shannon's equitability (E_H))

$$E = \frac{H^1}{Ln(S)} \quad (7)$$

Where S = is the total number of species in the vegetation.

RESULTS

There were 100 plant species belonging to 44 families in the CHHF. It was observed that there were 43 tree species, 19 shrub species, 18 herb species, and 20 climber species. Euphorbiaceae family was the most dominant (8 species), followed by Apocynaceae (7 species) while 25% the plant families had only 1species each (Figure 1). *Albizia zygia* had the highest IVI (48.22) and dominated the forest (Table 1). *Olax subscorpioidea* was the shrub with the highest relative frequency (30.29%) while *Alafia barteri* (0.29%), *Sarcocephalus latifolius* (0.29%) *and Tabernaemonta nacrassa* (0.29%) were least (Table 2). *Acanthus montanus* was the most abundant herb species (28.05%), while *Acanthospermum hispidum* (0.41%) and *Ananas comosus* (0.41%) were the least (Table 3). *Smilax kraussiana* (17.5%) was the climber with the highest frequency while, *Glyphaea brevis* (0.5%) was the least (Table 4).

The diversity indices did not vary from plot to plot with mean Shannon Weiner diversity index of 3.22, 2.22, 2.31 and 2.61 for trees, shrubs, herbs and climbers, respectively. Trees had the highest species richness (d = 5.79), while shrubs, herbs and climbers had species richness of 2.48, 2.34 and 2.62 respectively. However, the species evenness followed a different trend with the highest recorded for climbers (0.87), then trees (0.85), herbs (0.79) and the lowest for shrubs (0.75). The diameter class distribution revealed that trees within the 41-50 cm diameter class had the highest frequency (22.71%), followed by trees within the 31-40 cm diameter class, while those in the 131-140 cm diameter class were the least (Figure 3).

DISCUSSION

Herbs formed the largest portion of the individual plant population (34.84%), hence, the floristic composition followed this population trend: Herb> Climbers> Shrub> Trees. Many of the herbs, climbers and shrubs are of economic importance and are commonly collected by traditional medical practitioners in the CHHF environs. They include *Alchornea cordifolia, Spondias mombin, Combretum racemosum, Acanthospermum hispidum, Phyllantus amarus, Cissus aralioides, Acanthus montanus, Mucuna pruriens and Sarcocephalus latifolius.* The present population structure emanated from the opening of the forest canopy during forest disturbances in the past. The inflow of light to the forest floor is known to stimulate the growth of dense herbs, shrubs and woody lianas (Neeraj *et al*., 2001; Omeja *et al*. 2004). Nevertheless, the large population of climbers interlocked with mature trees suggests that the forest succession may be approaching climax as a result of the community effort towards forest protection (Hawthorne *et al.,* 2011; Makana and Thomas, 2006). This conservation effort over a 20 year period limited further canopy opening and disturbances, thus encouraging increased plant diversity in the ecosystem.

Table 1: Tree species composition in the Community Herbal Heritage Forest, Otun-Ekiti, Ekiti State, Nigeria

Species	Family	Frequency	Basal Area	Relative Frequency	Relative density	Relative dominance	IVI
Afzelia africana	Caesalpinaceae	3	0.85	1.67	2.35	1.39	5.41
Albizia ferruginea	Mimosaceae	11	2.51	6.11	5.65	4.11	15.88
Albizia zygia	Mimosaceae	33	14.12	18.33	6.75	23.13	48.22
Alstonia congensis	Apocynaceae	1	0.81	0.56	1.25	1.33	3.14
Anacardium occidenale	Anacardiaceae	1	0.43	0.56	1.25	0.7	2.51
Arthocleista djalonensis	Loganeaceae	2	0.28	1.11	1.25	0.46	2.82
Arthocleista vogelii	Loganeaceae	3	0.61	1.67	2.35	1	5.02
Antiaris toxicaria	Moraceae	2	1.41	1.11	1.25	2.31	4.67
Baphia nitida	Papilionaceae	2	0.45	1.11	1.25	0.74	3.1
Blighia sapida	Sapindaceae	1	0.12	0.56	1.25	0.2	2
Blighia unijugata	Sapindaceae	2	0.64	1.11	2.35	1.05	4.51
Bridelia ferruginea	Euphorbiaceae	2	0.15	1.11	2.35	0.25	3.71
Bridelia micrantha	Euphorbiaceae	2	0.46	1.11	1.25	0.75	3.12
Citrus sinensis	Rutaceae	2	1.8	1.11	1.25	2.95	5.31
Cola nitida	Sterculiaceae	4	1.39	2.22	1.25	2.28	5.75
Dialium guineense	Caesalpnaceae	1	0.21	0.56	1.25	0.34	2.15
Dracaena mannii	Dracaenaceae	2	1.86	1.11	1.25	3.05	5.41
Ekebergia capensis	Meliaceae	4	2.88	2.22	1.25	4.72	8.19
Elaeis guineensis	Arecaceae	6	3.26	3.33	2.35	5.34	11.03
Erythrophleum suavolens	Caesalpnaceae	1	0.28	0.56	1.25	0.46	2.27
Ficus capensis	Moraceae	6	1.7	3.33	5.64	2.79	11.76
Ficus exasperata	Moraceae	3	0.56	1.67	3.44	0.92	6.03
Ficus lutea	Moraceae	2	0.23	1.11	2.35	0.38	3.84
Funtumia elastica	Apocynaceae	2	0.35	1.11	2.35	0.57	4.04
Gmelina arborea	Lamiaceae	17	9.06	9.44	4.54	14.84	28.83
Harungana madagascariensis	Hypericaceae	2	0.77	1.11	2.35	1.26	4.73
Hildergardia barteri	Sterculiaceae	1	0.03	0.56	1.25	0.05	1.86
Holarrhena floribunda	Apocynaceae	13	3.15	7.22	5.64	5.16	18.03
Launaea taraxacifolia	Compositae	1	0.09	0.56	1.25	0.15	1.96
Lecaniodiscus cupanioides	Sapindaceae	11	3.13	6.11	4.54	5.13	15.78
Macaranga barteri	Euphorbiaceae	1	0.08	0.56	1.25	0.13	1.94
Mangifera indica	Anacardiaceae	2	0.76	1.11	1.25	1.25	3.61
Morus mesozygia	Moraceae	1	0.38	0.56	2.35	0.62	3.53
Parkia bigolobosa	Mimosaceae	3	0.09	1.67	1.25	0.15	3.07
Peltophorum pterocarpum	Caesalpinaceae	3	0.11	1.67	1.25	0.18	3.1
Morinda lucida	Rubiaceae	1	1.43	0.56	2.35	2.34	5.25
Margaritaria discoidea	Euphorbiaceae	5	0.38	2.78	2.35	0.62	5.75
Pycnanthus angolensis	Myristicaceae	2	0.37	1.11	1.25	0.61	2.97
Raphia hookeri	Arecaceae	3	0.52	1.67	1.25	0.85	3.77
Senna sieberiana	Caesalpinaceae	1	0.84	0.56	2.35	1.38	4.28
Spondias mombin	Anacardiaceae	4	0.51	2.22	3.44	0.84	6.5
Tetrapleura tetraptera	Mimosaceae	9	1.8	5	3.44	2.95	11.39
Trema orientalis	Ulmaceae	2	0.18	1.11	2.35	0.29	3.76
Total		180	61.04	100	100	100	300

Table 2: Shrub species in the Community Herbal Heritage Forest, Otun Ekiti, Ekiti State, Nigeria

Species	Family	Frequency	Relative Frequency	Relative Density
Abutilon mauritianum	Malvaceae	8	2.35	2.58
Alafia barteri	Apocynaceae	1	0.29	1.29
Alchornea cordifolia	Euphorbiaceae	11	3.24	4.71
Alchornea laxiflora	Euphorbiaceae	47	13.82	6.83
Allophylus africanus	Sapindaceae	17	5	6.83
Carpolobia lutea	Polygalaceae	25	7.35	8.96
Chassalia kolly	Rubiaceae	55	16.18	11.09
Cnestis ferruginea	Connaraceae	4	1.18	2.58
Coffee arabica	Rubiaceae	2	0.59	2.58
Hibiscus surattensis	Malvaceae	11	3.24	6.83
Hymenocardia acida	Hymenocardiacae	2	0.59	2.14
Icacina trachantha	Icacinaceae	7	2.06	4.71
Leea guineensis	Leeaceae	29	8.53	8.96
Sarcocephalus latifolius	Rubiaceae	1	0.29	1.29
Olax subscorpioidea	Olacaceae	103	30.29	13.22
Phyllanthus muellerianus	Euphorbiaceae	2	0.59	2.58
Tabernaemonta nacrassa	Apocynaceae	1	0.29	1.29
Thevetia neriifolia	Apocynaceae	3	0.88	2.58
Voacanga africana	Apocynaceae	11	3.24	8.96
Total		340	100	100

Table 3: Herb species composition in the Community Herbal Heritage Centre, Otun Ekiti, Ekiti State, Nigeria

Species	Family	Frequency	Relative Frequency	Relative Density
Acanthospermum hispidum	Compositae	2	0.41	2.22
Acanthus montanus	Acanthaceae	138	28.05	13.33
Ageratum conyzoides	Compositae	5	1.02	2.22
Ananas comosus	Bromeliaceae	2	0.41	2.22
Anchomanes difformis	Arecaceae	12	2.44	6.67
Andrographis paniculata	Acanthaceae	12	2.44	6.67
Aspilla africana	Asteraceae	46	9.35	6.67
Bryophyllum pinnatum	Crassulaceae	5	1.02	4.44
Chromolaena odorata	Asteraceae	53	10.77	8.89
Costus erythrophyllus	Costaceae	8	1.63	2.22
Crassocephalum rubens	Asteraceae	15	3.05	4.44
Drynaria laurentii	Polypodiaceae	78	15.85	8.89
Melanthera scandens	Asteraceae	17	3.46	2.22
Phyllantus amarus	Euphorbiaceae	4	0.81	2.22
Sida acuta	Malvaceae	30	6.09	6.67
Stachytarpheta indica	Verbenaceae	33	6.71	8.89
Synedrella nodiflora	Compositae	3	0.61	2.22
Waltheria indica	Sterculiaceae	29	5.89	8.89
Total		492	100	100

Table 4: Climber species composition in the Community Herbal Heritage Forest, Otun Ekiti, Ekiti State, Nigeria

Species	Family	Frequency	Relative Frequency	Relative density
Abrus precatorius	Papilionaceae	4	1	1.19
Adenia cissampeloides	Passifloraceae	8	2	2.57
Calopogonium mucunoides	Papilionaceae	6	1.5	1.19
Cissus aralioides	Vitaceae	16	4	7.93
Combretum racemosum	Combretaceae	24	6	8.33
Dalbergia lactea	Papilionaceae	13	3.3	3.57
Dioscorea bulbifera	Dioscoreaceae	50	12.5	10.71
Dioscorea mangenotiana	Dioscoreaceae	4	1	3.57
Gloriosa superba	Liliaceae	11	2.8	5.95
Glyphaea brevis	Tiliaceae	2	0.5	0.07
Ipomoea involucrata	Convolvulaceae	11	2.8	5.95
Mezoneuron benthamianum	Caesalpinaceae	41	10.3	9.51
Momordica charantia	Cucurbitaceae	8	2	1.19
Mucuna pruriens	Papilionaceae	13	3.3	3.57
Passiflora edulis	Passifloraceae	8	2	2.57
Passiflora foetida	Passifloraceae	4	1	1.11
Paullina pinnata	Sapindaceae	53	13.3	8.33
Pergularia daemia	Asclepiadaceae	23	5.8	5.95
Secamone afzelii	Asclepiadaceae	31	7.8	8.33
Smilax kraussiana	Smilacaceae	70	17.5	8.33
Total		400	100	100

The Shannon Weiner and Shannon's equitability indices are within the general limits of 1.5–3.5 for healthy forests and this indicates that CHHF had recovered to become highly diverse with trees dominating its structure and functions (Adekunle and Olagoke 2013; Makana and Thomas, 2006). The representation of 44 plant families in CHHF is additional evidence that the forest was recovering from previous disturbances. Plant species from the Apocynaceae, Caesalpinaceae, Euphorbiaceae, Moraceae, Papilionaceae, and Sapindaceae families were abundant in the CHHF. These families have been reported to constitute vegetation of lowland rainforest in Nigeria (Adebola and Awotoye, 2013; Adekunle, 2006; Olajuyigbe and Adaja, 2014). These families comprise plants of various life forms for instance; climbers, herbs and shrubs are all represented in the Euphorbiaceae family.

The important value index (IVI) which measures the relative importance of a species in a forest (Anning *et al.* 2009); revealed that *Albizia zygia* (48.22), *Albizia ferruginea* (15.88), *Gmelina arborea* (28.83), *Holarrhena floribunda* (18.03), *Lecaniodiscus cupanioides* (15.78) and *Tetrapleura tetraptera* (11.39) were important tree species in the CHHF (Table 1). The absence of pioneer trees and the dominance of long-lived early colonizers (*Albizia* and *Alstonia* spp.) suggest the recovery status of the forest (Aide *et al.* 2000). In addition, the presence of keystone species (*Ficus capensis, F. exasperata, F. lutea*) is a positive indication of the healthy state of the CHHF (Makana and Thomas 2006; Addo-Fordjour *et al.* 2009). *Gmelina arborea* which had been initially used as a live fence for demarcation of the forest was observed to have become dominant thus invading the forest. The high frequency of trees in the diameter classes <50 cm, suggest that there was a high level of disturbance and degradation in this forest in the past (Addo-Fordjour *et al*. 2009). This further explains the absence of large trees and low basal area of this forest. However, the somewhat inverted J curve, in which the abundance decreases with increasing tree diameter (Figure 3), suggests that there is a good natural regeneration process in which constituent species were being dispersed. Hence, the potential capacity of this forest community to recover over time (Adekunle and Olagoke 2008; Olajuyigbe and Adaja, 2014).

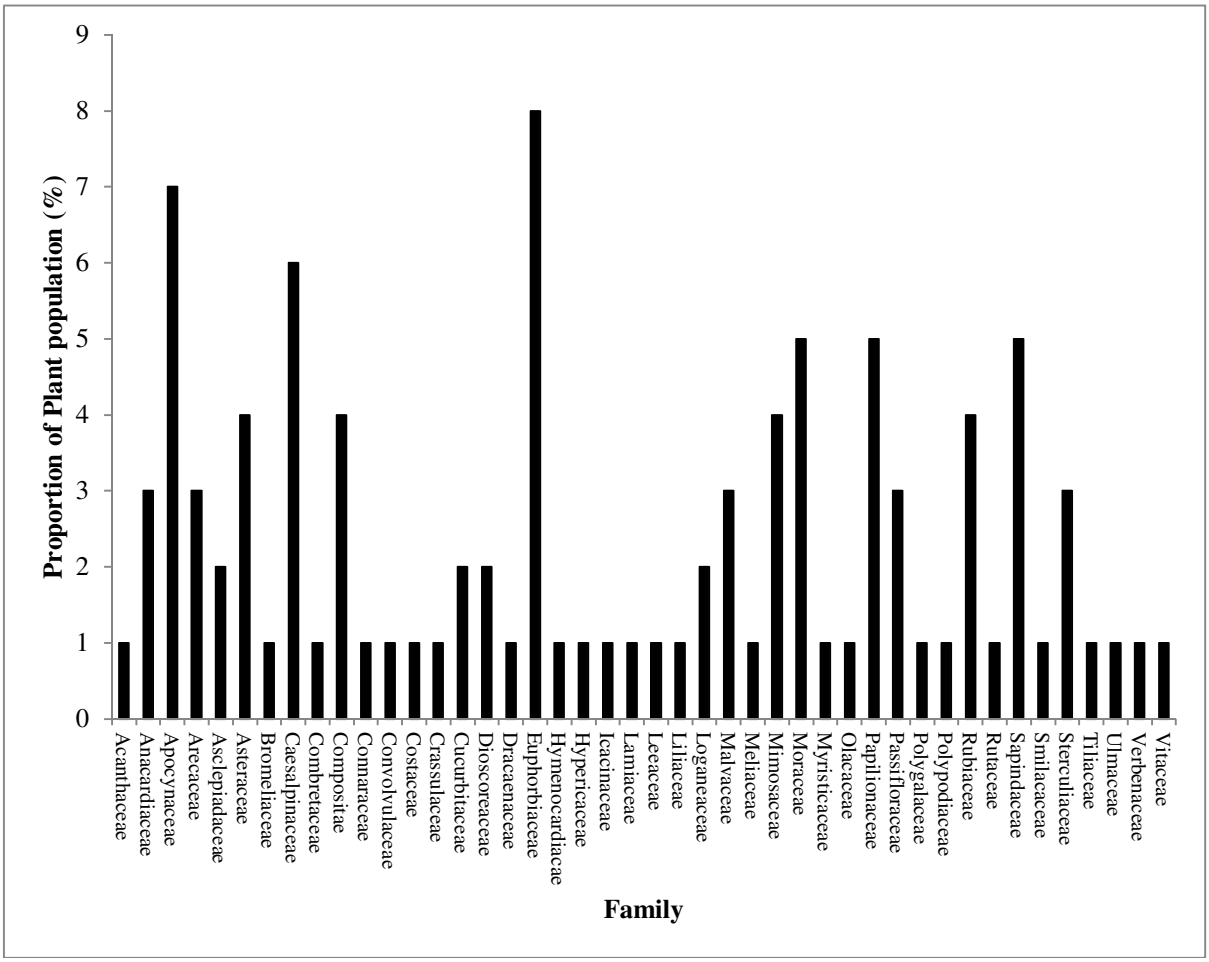

Figure 2: Plant family distribution in Community Herbal Heritage Forest, Otun Ekiti, Ekiti State, Nigeria

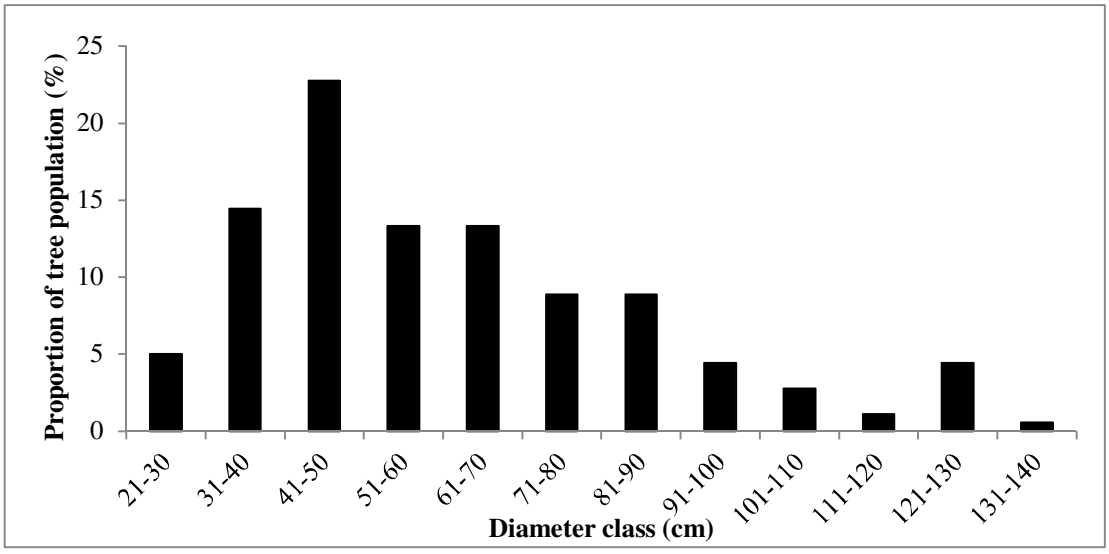

Figure 3: Plant family distribution in Community Herbal Heritage Forest, Otun Ekiti, Ekiti State, Nigeria

CONCLUSION

The Community Herbal Heritage Forest had become rich in plant diversity with many of the threatened species conserved and regenerated over time. The forest has a buffer capacity with a large population of wildlings, saplings, high rate of seed dispersal and other forest undergrowth. The community-based approach to forest restoration encourages the protection of plant genetic resources and would be useful in future efforts aimed at rehabilitating degraded lowland rainforest areas.

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