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Shrub Diversity Assessment of the Riparian Vegetation of Omo Biosphere Reserve, Ogun State, Nigeria

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ABSTRACT

Shrubs are any sort of woody, perpetual, thick plant that branch into stems or trunks at the base and smaller than trees. Shrub expansion has most likely been driven by anthropogenic activities and climate change effects, this occurs when forests are methodically aimed at for illegal tree cutting, hunting and conversion to agriculture which led to their degradation. This study assessed the diversity and distribution of shrub in the riparian forest of Omo Biosphere Reserve. It is stratified into three zones namely: Core Buffer and Transition. The Riparian forests along Major River and Streams were surveyed in the stratified zones and compared to the Upland vegetation. Stratified sampling was adopted and ninety plots (25 m × 25 m) were randomly assessed in the three strata of the study area. Sites were chosen based on accessibility within the zones and it was ensured that a variety of physiognomies were well represented. Shrub species list was obtained; biodiversity was assessed through Species richness, Shannon-index (H^+) and Equitability index of Pielou (E). Thirty six shrubs from 27 families were encountered in the riparian systems of Omo Biosphere Reserve. Shrub species along the streams were most abundant when compared to those along major rivers and uplands while the transition zone also had highest abundance in comparison to the buffer and core zones. The overall diversity of riparian forest Shrubs in Omo was 3.168. The three most abundant shrub species included *Rauvolfia vomitoria*, *Rinorea dentata*, *Icacina tricantha*. Family Euphorbiaceae Icacinaceae and Apocyanaceae were the most abundant families. This study shows high diversity and abundance in the composition of shrubs which indicates shrub encroachment and biodiversity alteration of the forest structure. Hence, there is a vital need to implement sustainable management strategies to restore and protect this forest ecosystem.

Keywords: Shrubs, Assessment, Biodiversity, Riparian vegetation.

Introduction

The natural vegetation associated with waterways and mostly represented by riparian forests (RFs) is credited to be among the most species-rich ecosystems all over the world, and particularly in tropical savanna ecosystem (Nilsson *et al.*, 1997). Riparian forests are essential areas for global biodiversity (Sala *et al.*, 2000); they are important because they guard key resources for mankind, such as stream environment, the quality and the source of water (Trimble, 1999), and harbour a diverse range of flora and physical structure (Woinarski *et al.*, 2000, Kokou *et al.*, 2002) including trees, shrubs, herbs, climbers, liana and ground flora.

Shrubs are any sort of woody, perpetual, thick plant that branch into stems or trunks at the base and smaller than trees, there expansion has most likely been driven by climate change (Archer *et al., 1995;* Sturn *et al.,* 2001), as shrub vegetation showed to be highly sensitive to changes in temperature (Sturn *et al.,*2001;Myers-Smith *et al.,* 2015a).Shrub also interact with the trees, as they compete for light, water and nutrients, although the tree layer plays the dominant role in the overall productivity of forest ecosystems, the understory vegetation, including its herbaceous and woody components, significantly contribute to nutrient cycling and soil carbon accumulation owing to substantially higher turnover rates as compared to overstory trees (Gilliam, 2007).

Shrub annual growth and growth rings can be highly linked to climate and can represent year-to-year variation in temperature, where a general increase in shrub growth is expected as a major response to global warming (Myers-Smith *et al.,* 2015b;Bar *et al.,* 2008). In addition, the age of shrubs or of their ramets has been shown to reflect environmental conditions (Rixen *et al*.,2004;Anadon-Rosell *et al.,* 2014). Other shrub traits, such as shoot length, number of leaf, abundance and biomass, have commonly been found to be sensitive indicators of environmental change and ecosystem functioning (Parsons *et al.,* 1994; Risen *et al.,* 2010).

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Materials and Method

Study site

The study area, Omo Biosphere Reserve is an internationally recognized and unique habitat whose landscape is partitioned as a result of biological population protection to meet up with the requirement of a typical biosphere reserve. It stretches North from latitudes 6° 35' to 7°05'N and East longitude 4° 19' to 4°40'E in Ijebu area of Ogun State, Southwestern Nigeria (Fig. 1). This study was carried out within the zonation of the reserve: The core (Strict Nature Reserve), the buffer zone and the transition zone within Omo Biosphere Reserve in Ogun State, Southwestern Nigeria.

Geologically the reserve lies on crystalline rocks of the undifferentiated basement complex which in the southern parts is overlain by Eocene deposits of the sand, clay and gravel. The soils are predominantly ferruginous tropical. The reserve is made up of several soil types but they all belong to the tertiary sediments. The sedimentary soils are mostly of the Iwo and Alagba series most of the soils are heavily leached being Oxic Tropudoles and Rhodic Paleudults. The vegetation of Omo Forest Reserve is mixed moist semi-deciduous rainforest. This can be distinguished into a dry evergreen mixed deciduous forest in the northern part and a

wet evergreen forest in the southern part. The mean annual rainfall ranges from about 1600 to 2000 mm with two annual peaks in June and September, with November and February being the driest months (Lowe, 1993).

The core zone covers about 460 hectares. The buffer zone surrounds the core area with an area of 8,165 hectares while the transition zone trans-borders the buffer zone and covers an area of 666,498.75 hectares. Each of these zones is separated by forest road, foot path, river streams or enclaves. Riparian areas within the biosphere consist of vegetation's along major rivers and streams. Representative sites were chosen along the major river, streams and Upland in each of the core, buffer, and transition zone.

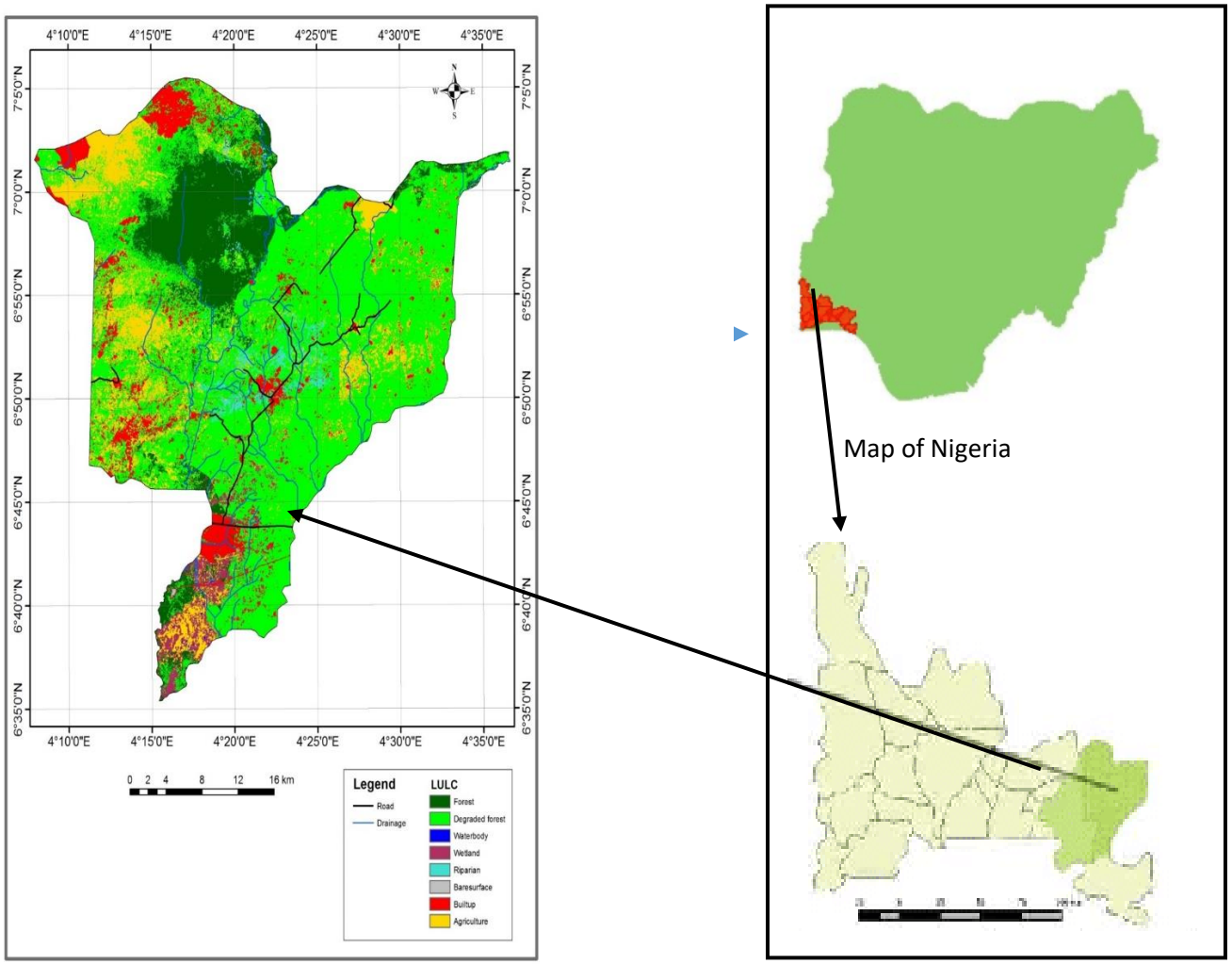

Figure 1: Map of Omo Biosphere Reserve, Ogun State, Nigeria.

Sampling design

Field inventory of shrub flora was adopted for data collection. The Reserve is stratified into Core, Buffer and Transition zones. Sites were chosen based on accessibility within the zones and ensured that variety of physiognomy were well represented. The sampling units were located inside each of the stratum within the zones where vegetation is relatively undisturbed and edge effect adequately overcome. Stratified sampling was adopted and ninety plots (25 m × 25 m) were randomly assessed in the three strata for identification and accurate floristic diversity assessment. Thirty plots each was sampled along the riparian vegetation of the core, buffer and transition zones out of which 15 plots were sampled along the riparian forest and 15 plots along the adjacent upland vegetation in each zone. All the shrub species within plots were identified, recorded and assigned to families. This was done to know the spatial distribution of shrubs. Also, the status of the species from each biosphere zone was documented.

Shrub Species Identification, Classification and Biodiversity Indices

The botanical name of every living shrub that was encountered in each sample plot was recorded for each of the study sites. In cases where the botanical name was not known immediately, such a shrub was identified by its commercial or local name. Such commercial or local names were translated to correct botanical names using Gbile (1984) and Keay (1989). Shrubs that could not be identified were tagged 'unknown'. Specimens of such unknown shrubs were collected and preserved for identification in the Forestry Herbarium Ibadan (FHI).

All shrubs were assigned to families and number of species in each family was obtained for species classification. Frequency of occurrence was obtained. Plants were identified on site with the help of taxonomists. The relative diversity was obtained for species diversity classification.

Data Analysis

Shrub Diversity

Species diversity of shrubs was assessed using these parameters: Differences in site diversity index (Shannon), Equitability index (Pielou), differences in site diversities (comparison of Sorensons diversity index).

Species Diversity and Ecosystem Diversity

The following biodiversity indices were used to obtain tree species richness and evenness within the forest in each community; they were also used as indices for comparing biodiversity among the communities' forest:

Important Value Index (IVI):This was obtained using

IVI = Relative density + Relative dominance + Relative abundance……(1)

Species Relative Density(RD): These were obtained using the formula.

$$\text{Density} = \frac{\textit{No of a Species per unit area}}{\text{Total number af all species}} \ldots\ldots\ldots\ldots\ldots(2)$$

$$\text{RelativeDensity} = \frac{\textit{No of a Species per unit area}}{\text{Total number af all species}} \times 100 \ldots\ldots\ldots\ldots\ldots(3)$$

Species Relative Frequency (RD): These were obtained using the formula.

$$\text{Frequency} = \frac{\textit{No of a uadrats in which a species is enumerated}}{\text{Total number af quadrats}} \ldots\ldots\ldots\ldots\ldots(4)$$

$$\text{RelativeDensity} = \frac{\textit{Frequency of a specie}}{\text{Total freuency af all species}} \times 100 \ldots\ldots\ldots\ldots\ldots\ (5)$$

Relative Dominance was obtained using the formula

$$\text{Dominance} = \frac{\textit{Total basal area of a specie}}{\text{Total area sampled}} \ldots\ldots\ldots\ldots\ldots(6)$$

$$\text{RelativeDominance} = \frac{\textit{Dominance of a specie}}{\text{Total Dominanace all species}} \times 100 \ldots\ldots\ \ldots(7)$$

Community Diversity

This was obtained using a mathematical formula that takes into account the species richness and abundance of each species in the ecological community.

Shrub Diversity Index

This was calculated using the Shannon-Wiener diversity index (Kent and Coker, 1992):

$$H^1 = -\sum_{i=1}^{S} \text{pi} \ln(\text{pi}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (8)$$

Where:

H^1 = Shannon-Weiner diversity index

S = Total number of species in the community

Pi= Proportion of S made up of the ith species

Ln=natural logarithm

Species Evenness in each community will be determined using Shannon's equitability (E_H):

$$E_H = \frac{H}{lnS} = \frac{\sum_{i=1}^{S} \text{p1} \ln(\text{p1})}{\ln S} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

E_H is the Shannon diversity index,

S is the total number of species in the community,

pi is the proportion of a species to the total number of plants in the community and

Ln is the natural logarithm.

Sorensen's Species Similarity Index (SI) of Nath*et al*., (2005) was used to compare diversity across the three ecological zone.

$$SI = \left[\frac{2C}{A+B}\right] \times 100 \quad (10)$$

C is the total number of common species;

while A is the no of species in community A

and B is the no of species in community B

Results

Shrub Diversity in the Riparian vegetation of Omo Biosphere Reserve

Shrub diversity across the zones is shown in Table 1. Thirty six shrub species were encountered in 90 plots with 24 of these shrub species found strictly along the riparian forest (Major rivers and streams). The three most important shrub species included *Rauvolfia vomitoria* (14.08), *Icacina tricantha* (12.96) and *Rinoreadentata* (10.35) while the least important species included *Acacia ataxacantha, Ananas comosus, Cnestis ferruginea, Lonchocarpuscyanescens, Napoleonaea vogelii, Solanum terminale* (0.53) (Table 1)

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Table 1: Shrub Diversity in Omo Biosphere Reserve

Species	Family	Major River	Streams	Upland	Total	Frequency	Density	RF	RD	IVI
Acacia ataxacantha	Mimosoideae		1		1	1	0.0016	0.699	0.373134	0.536218
Alchornealaxiflora	Euphorbiaceae		12		12	8	0.0192	5.594406	4.477612	5.036009
Alchorneacordifolia	Euphorbiaceae	10	4		14	8	0.0224	5.594406	5.223881	5.409143
Ananascomosus	Bromeliaceae		1		1	1	0.0016	0.699301	0.373134	0.536218
Bambusa vulgaris	Poaceae	3			3	1	0.0048	0.699301	1.119403	0.909352
Brideliaferruginea	Euphorbiaceae		6		6	2	0.0096	1.398601	2.238806	1.818704
Carpolobialutea	Polygalaceae	2	1		3	2	0.0048	1.398601	1.119403	1.259002
Chassaliakolly	Rubiaceae		3		3	1	0.0048	0.699301	1.119403	0.909352
Chromolaenaodorata	Asteraceae	2	7	1	10	6	0.016	4.195804	3.731343	3.963574
Citrus sinensis	Rutaceae	1		1	2	2	0.0032	1.398601	0.746269	1.072435
Cnestisferruginea	Connaraceae		1		1	1	0.0016	0.699301	0.373134	0.536218

Combretum sp.	Combretaceae		1	3	4	2	0.0064	1.398601	1.492537	1.445569
Deinbolliapinnata	Sapindaceae	2			2	1	0.0032	0.699301	0.746269	0.722785
Diospyrosbarteri	Ebenaceae	4			4	1	0.0064	0.699301	1.492537	1.095919
Dracaena manni	Agavaceae	8	2	10	20	6	0.032	4.195804	7.462687	5.829245
Euadeniatrifoliolata	Capparaceae		1		1	2	0.0016	1.398601	0.373134	0.885868
Glyphaeabrevis	Tiliaceae			1	1	2	0.0016	1.398601	0.373134	0.885868
Grewiapubescens	Tiliaceae	3	3		6	2	0.0096	1.398601	2.238806	1.818704
Harunganamadagascariensis	Guttiferae		5		5	1	0.008	0.699301	1.865672	1.282486
Hippocrateaindica	Celastraceae	2			2	1	0.0032	0.699301	0.746269	0.722785
Icacinatricantha	Icacinaceae	8	12	12	32	20	0.0512	13.98601	11.9403	12.96316
Icacinamanni	Icacinaceae	8		2	10	6	0.016	4.195804	3.731343	3.963574
Lonchocarpuscyanescens	Fabaceae		1		1	1	0.0016	0.699301	0.373134	0.536218

Macarangabarteri	Euphorbiaceae		13		13	6	0.0208	4.195804	4.850746	4.523275
Mallotusoppositifolius	Euphorbiaceae		5	1	6	4	0.0096	2.797203	2.238806	2.518004
Maicarangabarteri	Euphorbiaceae		1		1	2	0.0016	1.398601	0.373134	0.885868
Microdesmispuberula	Pandaceae	5	1		6	4	0.0096	2.797203	2.238806	2.518004
Napoleonaeavogelii	Anarcardiaceae			1	1	1	0.0016	0.699301	0.373134	0.536218
Olaxsubscorpioidea	Olacaceae	8	1	5	14	10	0.0224	6.993007	5.223881	6.108444
Pavettacorymbosa	Rubiaceae	2			2	2	0.0032	1.398601	0.746269	1.072435
Phyllanthusmuellerianus	Phyllanthaceae			2	2	1	0.0032	0.699301	0.746269	0.722785
Quassiaamara	Simaroubaceae		2		2	1	0.0032	0.699301	0.746269	0.722785
Rauvolfiavomitoria	Apocyanaceae	12	21	5	38	20	0.0608	13.98601	14.1791	14.08256
Rinoreadentata	Violaceae	11	18	4	33	12	0.0528	8.391608	12.31343	10.35252

Salaciapallescens	Celastraceae	5			5	1	0.008	0.699301	1.865672	1.282486
Solanumterminale	Solanaceae			1	1	1	0.0016	0.699301	0.373134	0.536218
36		96(18)	123(24)	(49)14	268	143	0.4288	100	100	100

Table 2 shows that the Shannon index varies from 0.50 to 3.28through the major rivers and streams in the core, buffer and transition zones. Riparian forests shrub along all streams has higher diversity (3.28), along all the streams (2.70) and the uplands (2.47). The overall riparian forest (along major rivers and stream) shrub diversity was3.16.The Equitability index of Pielou is 0.89.Total number of shrubs in the Uplands was 14, major river (21) and highest in the stream(37) while Abundance of shrubs was also higher in the stream(107) and lower in Upland (14).The percentage abundance of the ten most common species are shown in table 3. The ten most important shrubs had a total percentage of 73.13while the remaining 100 species had 26.87%. While table 4 also shows the percentage abundance of the 10 most important families to be 69.8% and the remaining 17 families had 30.1%.

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Table 2: Floristic and Stand Characteristics of Riparian Shrub Species in Omo Biosphere

Region	Site	Noof shrub	Abundance N	Dominance	Simpsom	Shannon	Evenness
	Major river	3	9	0.358	0.642	1.061	0.961
CORE	Stream	16	23	0.073	0.926	2.691	0.921
	Upland	2	10	0.680	0.320	0.500	0.824
	Major river	9	43	0.157	0.840	1.983	0.807
BUFFER	Stream	10	39	0.129	0.870	2.144	0.853
	Upland	3	12	0.375	0.625	1.04	0.942
	Major river	9	38	0.188	0.811	1.871	0.721
TRANSITION	Stream	10	45	0.158	0.841	2.04	0.768
	Upland	9	21	0.156	0.843	2.001	0.822
All region	UPLANDS	14	40	0.095	0.905	2.476	0.845
	MAJOR RIVERS	21	93	0.072	0.927	2.792	0.776
	STREAMS	36	107	0.048	0.951	3.280	0.738
Shrubs in the RiparianForest ofOmo	**All major rivers andstreams**	**34**	**109**	**0.054**	**0.945**	**3.168**	**0.698**

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Table 3: Riparian Forest Shrub Species Dominance: Number of Individuals and % Abundance of 10 Most Important Common Species

SPECIES	Absolute abundance	Relative Abundance (%)
Rauvolfiavomitoria	38	14.17
Rinoreadentata	33	12.31
Icacinatricantha	32	11.94
Dracenamanni	20	7.46
Olaxsubscorpioidea	14	5.22
Alchorneacordifolia	14	5.22
Macarangabarteri	13	4.85
Alchornealaxiflora	12	4.47
Chromolaenaodorata	10	3.73
Icacinamanni	10	5.10
Total of the 10 most important shrub species	196	73.13
Total of the remaining 26 shrub species	72	26.87
Overall total of the 110 shrub species	**268**	**100**

Table 4 : Riparian Forest Shrub Family Dominance: 10 Most Important Family

SPECIES	Absolute abundance	Relative Abundance (%)
Euphorbiaceae	52	19.40
Icacinaceae	42	15.67
Apocyanaceae	38	14.17
Violaceae	33	12.31
Agavaceae	20	7.46
Olacaceae	14	5.22
Asteraceae	10	3.73
Tiliaceae	7	2.61
Celastraceae	7	2.61
Pandaceae	6	2.23
Total of the 10 most important shrub families	229	85.44
Total of the remaining 26 shrub families	39	14.55
Overall total of the 46 shrub families	**268**	**100**

Discussion

The study revealed the assessment of variations in the shrub species composition of the riparian forest of Omo Biosphere Reserve, Nigeria. Shrub species along the streams were most abundant when compared to those along major rivers and uplands while the uplands has the least. This may be as a result of the low intensity in the rate of flow of water which enables inundation and support of seed settlement for germination. The high density of species associated with the streams along the riparian forest is undoubtedly due to the fact that these zone are of unique characteristics in the river activity and this is of importance to flora and fauna conservation.

The 36 shrub species belonging to 27 families recorded in this result is relatively high in comparison with 18 shrubs belonging to 15 families in a similar study that assessed the diversity of shrub species of Gurara forest of Kaduna State (Adaaja, 2017).While the result shows a similarity in the abundance of the tree species along riparian forest of the stream in Omo biosphere reserve.(Olatidoye 2019). Generally, biodiversity in natural riparian areas is sustained by high spatial and temporal variability in the environmental conditions reflecting strong environmental gradient that exists at different scales (Ward *et al*., 2002). In particular, the complexity in the geomorphology and hydrology increased with increasing stream size (Dahl *et al*., 2007).

The overall diversity of riparian forest Shrubs in Omo was 3.16which is a relatively high value. This is lower than the diversity of trees species (3.74) within the sampling area (Olatidoye *et. al.* 2019). Lower shrub diversity could be attributed to the high conservation status within the biosphere reserve. Changes in the abundance and height of shrubs could lead to considerable shifts in both the structure and species composition of a plant community (kumordzi, 2016; Walker 2006).Shrubs of the riparian forest found along the stream has higher diversity (3.28). This could be as a result of the reduction in turbulence and slow intensity of flow along the stream which gives room for sedimentation of seeds for greater germination.

The Simpson's index (D') obtained 0.945 which is an indication of high diversity value is in agreement with Young and Swiacki (2006) who stated that diversity was made up of species present and the relative abundance of those species. The higher the value of index, the higher the diversity index (Ojo 2004). The overall evenness of shrubs was 0.698 for Omo Biosphere Reserve is an indication of high species distribution. This result is similar to the findings of Onyekwelu *et al*., (2007) who reported that the higher the species distribution, the more the evenness of species.

The three most common shrubs were *Rauvolfia vomitoria* (14.17%) *Rinoreadentata* (12.31%) *Icacinatricantha* (11.94%). Family Euphorbiaceae Icacinaceae and Apocyanaceae were the most abundant families. Family Euphorbiaceae has a relative abundance of about 19% of the 27 families present. In the Dja Fauna Reserve, Cameroun, the Euphorbiaceae, Rubiaceae, Annonaceae, Meliaceae, Caesalpinaceae, Sapindaceae and Sapotaceae have the highest species (Sonke and Lejoly, 1998). Akoegninou (1984) found 93 families with the Rubiaceae, Papilionodae, Poaceae, Euphorbiaceae and Apocynaceae as the most common in a dense semi-deciduous forest in southern Benin. This findings have similar results of family Euphorbiaceae and family Apocyanaceae and contribute 48% of the entire shrubs.

Along the zones, diversity is higher in the Transition region (3.024), this is due to human

activities such as deforestation and degradation that has exposed the zone to the invasion of shrubs since it is to be the most threatened zone of the biosphere reserve where dwellers carry out logging activities and obtain there source of livelihood. Diversity was lower in the core zone (2.822) since the zone is exemplified by high canopy cover, it is an extremely restricted area from all form of activities, the zone exemplifies an undisturbed natural forest and this could have contributed to the low diversity of shrubs.

Conclusion

The paper established that shrub species composition along the riparian forest of Omo Biosphere Reserve has high diversity and abundance most especially in the transition zone, this indicates shrub encroachment as a result of forest degradation and farming activities going on in a typical forest Reserve causing a decline in the riparian vegetation and biodiversity alteration in the forest structure specially in the sensitive part of the forest that serves as habitat for specific flora and fauna as well as reproduction site for some animals. Hence, there is a vital need to implement sustainable management strategies to restore and protect this forest ecosystem to prevent further invasion into the buffer and core zones of the reserve.

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