Journal of Forestry Research and Management. Vol. 19(2).105-115; 2022, ISSN 0189-8418

www.jfrm.org.ng

ANNOTATED CHECKLIST OF UNDERSTOREY PLANT SPECIES OF A 36-YEAR-OLD *Pinus caribaea* Morelet var. *hondurensis* Barrett and Golfari (Pinaceae) PLANTATION IN UMUAHIA, NIGERIA

[1] Ariwaodo Joseph O, [2] Odeyemi Solomon, *[2]Obidike-Ugwu Evelyn O. [1] Eric Esther E. and [1]Esemuede I. E.

[1] Swamp Forest Research Station, Onne, Rivers State.
[2] Humid Forest Research Station, Umuahia, Abia State
eloeve8@gmail.com

ABSTRACT

There is existing paucity of information on under storey plant species in established plantation ecosystem in Nigeria. The taxonomic inventory embarked upon, involved repeated intensive field collection, identification and registration of occurring taxa. Aimed at providing an updated checklist of native species of vascular plants beneath the mono-canopy structure of a 36-year-old *Pinus caribaea* (Pine) plantation. Total of 78 taxa belonging to 72 genera and 39 families were identified and documented. Family Fabaceae was diverse with 11 species followed by Moraceae (6), Apocynaceae (6), Rubiaceae (5), and Euphorbiaceae (4). These 5 families contributed 41.03% of the vascular plant diversity or 38.89% of the genera. The species *Pityrogramma calomelanos* (L) Link (Family: Hemionitidaceae) was the only member of the Ferns and Fern allies (Pteridophytes) recorded. The genera *Ficus* L and *Dioscorea* L have the most diverse species with 3 each. Sixty-eight (68) genera or 94.4% of the total enumerated understorey vascular plant species were represented by single species. Thus, showed limited diversity of species in the habitat with strong implication for unadopted plants. Among occurring life forms, trees were the most dominant group with 32 species or 41%, followed by shrubs with 20 species (25.6%), climbers with 19 species (24.4%), and herbs with 7 species (9.0%). Plant valued for their ethnobotanical usages, such as leafy vegetables, spices and herbal medications were also recorded from the ecosystem. Thus, the taxonomic inventory revealed the rich diversity of native understorey plant species present and provides baseline data to guide biodiversity management.

Keywords: vascular plant, monocanopy, understorey, taxa, ethnobotanical, ecosystem.

Introduction

Plantation forests of an intensively managed stand of fast-growing exotic tree species such as *P. caribaea* (Pine) are among the major land-use change experienced in Nigeria (Odiwe *et al*, 2012). The purpose of the introduction of these plant species into the nation's landscape was to curb pressure on native tree species and ensure an adequate supply of the much-needed pulpwood and commercial timber. However, the plantation of exotic tree species has been reported in many studies to impact biodiversity, and their ability to conserve and harbour native flora is highly debated (Harrington and Ewel, 1997; Nagaike *et al*., 2003; Chapin *et al* 2000; Odiwe *et al.*, 2012; Onyekwelu and Olabinwonu, 2016).

Biodiversity loss of tropical forests due to anthropogenic activities has assumed a global problem (Sukumaran *et al.*, 2008). The type and intensity of land-use change as a result of

the conversion of degraded natural forestland into plantation of mixed or monoculture exotic tree species may influence the diversity of species at the understorey plant community layer. This is based on the fact that scientific evidence had revealed that much of the biodiversity harboured in tropical forests reside in the understorey vegetation, resulting in its inclusion in biodiversity assessment studies (Tchouto *et al.*, 2006; Rahman *et al.*, 2016). Generally, understorey plant species play a key role in ecological functions and processes. They are often considered indicators of soil moisture and nutritional status and contribute to the degree of biodiversity in forest ecosystems by influencing long-term successional patterns (George and Buzzaz, 1999; Royo and Carlson, 2003; Oladoye 2015; Zhang *et al.*, 2015).

In Nigeria, there have been a relative number of studies on native flora diversity under an exotic tree plantation. Previous ecological research work had investigated a few exotic tree species which include; *Gmelina arborea* Roxb (Onyekwelu and Fawupe, 2008; Onyekwelu and Olabinwonu, 2016); *Theobroma cacao* L, *Citrus sinensis* (L) Osbeck (Odiwe *et al.*, 2012) and *Tectona grandis* L (Olajuigbe *et al.*, 2017). However, there is existing paucity of information on native flora diversity under pine plantations in Nigeria, to provide baseline data useful in biodiversity management. Most importantly, members of the genus Pinus L. (*P.halepensis* L, *P.densiflora* Sieb et Zucc, *P. monophylla* Torr and Frem, *P.sylvestris* L) had been implicated in literature to exhibit allelopathic effects due to the presence of phytotoxic compounds (monoterpenes) produced and accumulated within the pine needle tissue (Wilt *et al.*, 1993a and b; Nektarius *et al.*, 2005; Bulut and Demir, 2007). This phytocompound when delivered to the forest floor by defoliation of the needles plays an important role in the formation of the forest floor, by its inhibitory activity on the germination and growth of understorey species (Bulut and Demir 2007; Kimura *et al*, 2015). However, in the context of taxonomy and in line with the main objective of this study, the importance of a biological checklist which involves the collection of species resource information, namely species inventory, as stated by Heywood *et al*, (1997) and Mbuni *et al*. (2019), is the primary component of the biodiversity catalogue and the easiest to understand and operate, with the nomenclature being the chief focus, as it is fundamental in the communication about plants and the key to biodiversity status. This present study was, therefore, embarked upon, to identify and document occurring vascular flora as a contribution to the floristic taxonomy of understorey plant species in an old-growth exotic monoculture pine plantation in Southeastern Nigeria.

Materials and Methods

The study was carried out in the *P.caribeae* (Pine) Research plot established in 1983. The pure pine plot has remained relatively undisturbed over the years. It covers an area of 0.7 hectares within the Humid Forest Research Station, Forestry Research Institute of Nigeria (FRIN) substation at Umuahia, Abia State, Nigeria. The Station's location lies on latitude 5^{o} 30`48``N to $5^{o}$ 31`15``N and longitude 7^{o} 31`32``E to $7^{o}$ 31`03``E of the Greenwich meridian, at an altitude area of up to 122m above sea level (Fig. I) while the plantation lies between latitude 5^{o} 31`0.99``N to $5^{o}$ 31`1.94``N and longitude 7^{o} 31`35.37``E to $7^{o}$ 31`38.94``E. The vegetation is typical of the lowland rainforest of Southeastern Nigeria. The rainfall pattern is bimodal with peaks around June to July and September to

Journal of Forestry Research and Management. Vol. 19(2).105-115; 2022, ISSN 0189-8418
www.jfrm.org.ng

October. Annual rainfall is 2238 mm, minimum and maximum temperatures are 23^{o}C and 30^{o}C respectively.

The relative humidity is 86.4% (Ariwaodo and Harry-Asobara, 2015). The soil of the area is derived from the Precambrian basement complex and the soil type is ultisols. Another site factor from the study area viz; a poor light influx of the closed monocanopy structure and the annual litter production had earlier been reported (Nzegbule and Ogbonna, 2007).

The taxonomic survey was initiated in January 2019 and completed in September 2019 to cover the dry and rainy season period. Plot sizes of 10m by 10m were laid along the established transect line before the commencement of enumeration. This study involved repeated intensive taxonomic field collection, identification and registration of occurring naturally regenerated understorey vascular plant species within the monoculture pine plantation. Each taxon was determined using taxonomic keys provided in relevant taxonomic literature such as Flora of West Tropical Africa (Hutchinson and Dalziel, 1972) and Trees of Nigeria (Key, 1987). Furthermore, each plant collection was prepared, compared and authenticated with registered voucher specimens deposited at the Forest Herbarium Ibadan (FHI) listed in Holmgren *et al* (1990) following conventional taxonomic practices. The concept of families follows Hutchinson and Dalziel (1954-1972). Families are arranged in alphabetical order under each category. Binomial nomenclature of registered taxa follows International Plant Names Index (IPNI).

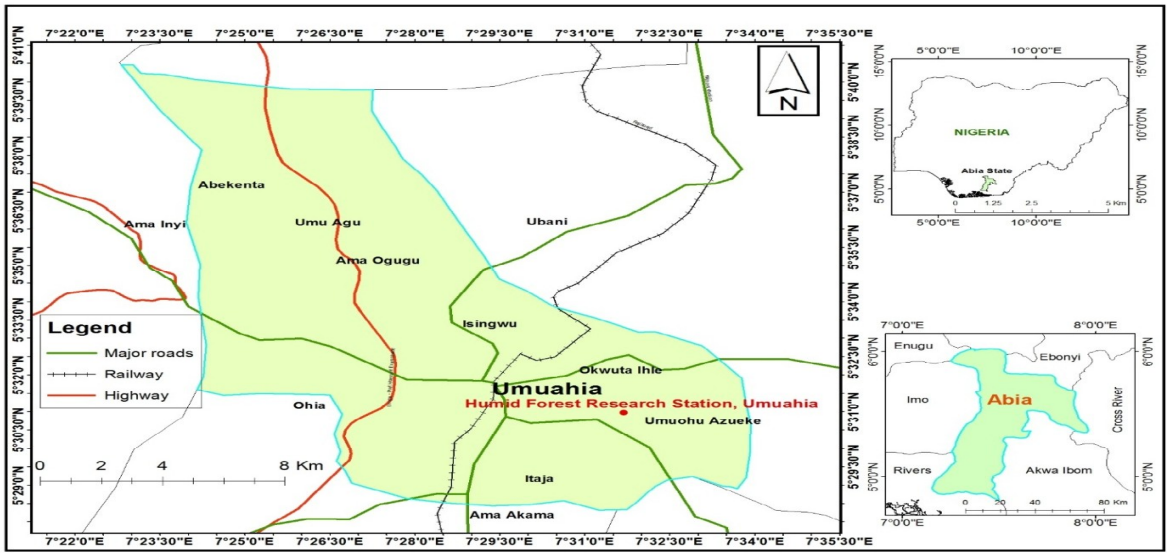

Fig. 1: Map of the Study Area

Journal of Forestry Research and Management. Vol. 19(2).105-115; 2022, ISSN 0189-8418
www.jfrm.org.ng

Results and Discussion

The study identified and recorded a total of seventy-eight (78) vascular plant species belonging to seventy-two (72) genera and thirty-nine (39) families under the monoculture Pine plantation (Table 1 & 2, Fig. 2). Representative families registered comprise: one (1) Pteridophytes, one (1) Gymnosperms and thirty-seven (37) Angiosperms (30 Dicots & 7 Monocots). The number of species per family ranges from 1 to 11. The family Fabaceae was the most diverse with 11 species (Caesalpinioideae-2; Mimosoideae -2, Papilinioideae -7). It was closely followed by the families – Moraceae (6), Apocynaceae (6), Rubiaceae (5) and Euphorbiaceae (4). These 5 families contributed about 41.03% of the vascular plant diversity or 38.89% of the genera (Table

Table 1: List of vascular plant species identified in the study area.

S/N	Plant group	Scientific name	Family	Habit
1	**Pteridosperms**	*Pityrogramma calomelanos* (L) Link	Hemionitidaceae	Fern/Herb
2	**Gynosperms**	*Gnetum africanum* Welw	Gnetiaceae	Climber
	Angiosperms			
	Dicotyledons			
3		*Dialum guineense* Willd	Fabaceae	Tree
4		*Triclisa subcordata* Oliv	Menispermaceae	Climber
5		*Cissus arguta* Hook.f	Vitaceae	Climber
6		*Icacinia trichantha* Oliv	Icacinaceae	Scrambling shrub
7		*Anthonotha macrophylla* P.Beauv	Fabaceae	Tree
8		*Cnetis ferruginea* Vahl ex DC	Connaraceae	Scrambling shrub
9		*Brysocarpus coccineus* Schumach et Thonn	Connaraceae	Shrub
10		*Cola millenii* k.Schum	Sterculiaceae	Tree
11		*Aristolochia ringens* Vahl	Aristoloschiaceae	Climber
12		*Agelaea obiqua* (P.beauv) Baiil	Connaraceae	Shrub
13		*Autiaris toxicaria* Var.welwitschii	Moraceae	Tree
14		*Macaranga barteri* Mull Arg	Euphorbiaceae	Tree
15		*Tabernaemontana pachysiphon* Stapf	Apocynaceae	Tree
16		*Manniophyton fulvum* Mull. Arg	Euphorbiaceae	Scrambling shrub
17		*Milletia aboensis* (Hook. f) Baker	Fabaceae	Scrambling shrub
18		*Sterculia tragacantha* Lindl.	Sterculiaceae	Tree
19		*Leptoderis micrantha* Dunn.	Fabaceae	Scrambling shrub
20		*Bartaria fistulosa* Mast.	Passifloraceae	Small tree
21		*Abrus precatorius* L	Fabaceae	Climber
22		*Pyrenacantha staudtii* (Engl.) Engl	Icacinaceae	Climber
23		*Lecaniodiscus cupanioides* Planch ex Benth	Sapindaceae	Shrub
24		*Funtumia elastica* (Preuss) Stapf	Apocynaceae	Tree
25		*Lonchocarpus cyanescens* (Schum et Thonn) Benth	Fabaceae	Wood climber
26		*Pterocarpus osun* Craib	Fabaceae	Tree
27		*Ceiba pentandra* (L.) Gaertn	Bonbacaceae	Tree
28		*Napoleona inperialis* P. Beauv.	Lecythidaceae	Shrub
29		*Canarium schweinfurthii* Engl.	Burseraceae	Tree
30		*Lovoa trichilioides* Harms	Melieceae	Tree
31		*Hippocratea pallens* Planch ex Oliv	Hippocrateaceae	Woody climber
32		*Chassalia kolly* (Schumach) Happer	Rubiaceae	Under shrub
33		*Milicia excelsa* (Welw) C.C.Berg	Moraceae	Tree

34		*Carpolobia lutea* G. Don	Polygalaceae	Shrub
35		*Allophylus africanus* P. Beauv.	Sapindaceae	Shrub
36		*Anthocleista djalonensis* A. Chev	Longaniaceae	Tree
37		*Rauvolfia vomitoria* Afzel	Apocynaceae	Shrub
38		*Voacanga africana* Stapf.	Apocynaceae	Small tree
39		*Asystasia gangetica* (L.) T. Anderson	Acanthaceae	Herb
40		*Albizia adianthifolia* (Schum) W.F Wright	Fabaceae	Tree
41		*Microdesmis puberula* Hook. f ex Planch	Pandaceae	Shrub
42		*Psydrax subcordata* (DC) Bridson	Rubiaceae	Tree
43		*Paullinia pinnata* L.	Sapindaceae	Climber
44		*Ficus exasperate* Vahl	Moraceae	Tree
45		*Baphia nitida* Lodd	Fabaceae	Shrub
46		*Secamone afzelii* (Roem et Schult) K.Schum	Asclepiadaceae	Climber
47		*Tetracera alnifolia* Willd	Dilleniaceae	Woody climber
48		*Cissampelos oweriensis* P. Beauv. ex DC	Menispermaceae	Climber
49		*Ficus sur* Forssk	Moraceae	Tree
50		*Mallotus oppositifolius* (Geiseler) Mull. Arg	Euphorbiaceae	Shrub
51		*Rytigyna nigerica* (S. Moore) Robyns	Rubiaceae	Shrub
52		*Newbouldia laevis* (P. Beauv) Seem ex Bureau	Bignoniaceae	Tree
53		*Ficus Mucuso* Welw. ex Ficalho	Moraceae	Tree
54		*Musauga cecropioides* R.Br. ex Tedlie	Moraceae	Tree
55		*Pycananthus angolensis* (Welw) Warb	Myristicaceae	Tree
56		*Pterocarpus santalioides* L' Harm ex DC	Fabaceae	Tree
57		*Hedranthera barteri* (Hook.f) Pichon	Apocynaceae	Shrub
58		*Bridelia micrantha* (Hochst) Baill	Euphorbiaceae	Small tree
59		*Euadenia trifoliolata* (Schumach et Thonn) Oliv	Capparidaceae	Shrub
60		*Monodora tenuifolia* Benth	Annonaceae	Tree
61		*Morinda lucida* Benth	Rubiaceae	Tree
62		*Massularia acuminate* (G.Don) Bullock ex hoyle	Rubiaceae	Shrub
63		*Albizia zygia* (DC) J.F.Machr	Fabaceae	Tree
64		*Sphenocentrum jollyanum* Pierre	Menispurmaceae	Shrub
65		*Spathodea canpanulata* P.Beauv	Bynoniaceae	Tree
66		*Landolphia owariensis* P.Beauv	Apocynaceae	Woody climber
67		*Conbretum racemosum* P.Beauv	Combretaceae	Climber
68		*Coccinia barteria* (Hook. F) Keay	Cucurbitaceae	Climber
69		*Acanthus montanus* (Nees) T.Anderson	Acanthaceae	Herb
	Monocotyledons			
70		*Anchomanes difformis* (Blume) Engl.	Araceae	Herb
71		*Dioscorea praechensilis* Benth	Discoreaceae	Climber
72		*Dioscorea bublifera* L	Discoreaceae	Climber
73		*Dioscorea dumentorum* (Kunth) Pax	Discoreaceae	Climber
74		*Smilax anceps* Willd	Smilacaceae	Climber
75		*Costus afer* Ker-Gawl	Costaceae	Tall herb
76		*Crinum jagus* (J.Thomps) Dandy	Amaryllidaceae	Herb
77		*Elaeis guineensis* Jacq	Arecaceae	Tree
78		*Palisota hirsuta* (Thunb) K. Schum	Commelinaceae	Herb

Table 2. Statistical summary of understorey plant species in a 36 years old Pine Plantation in Nigeria

Group	Pteridophytes	Gymnosperms	Angiosperms		Total
			Dicotyledons	Monocotyledons	
Families	1	1	30	7	39
Genera	1	1	63	7	72
Species	1	1	67	9	78

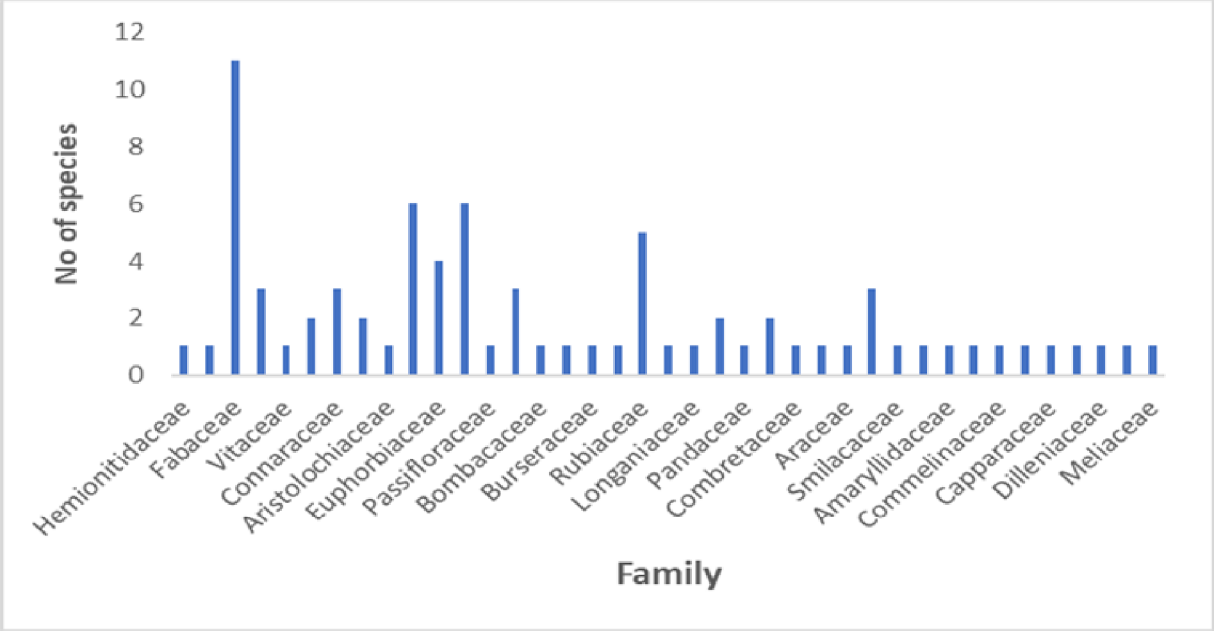

Fig 2: Family distribution of understorey plants documented

3 & 4). Ayodele and Yang (2012) had earlier listed the 5 dominant understorey vascular plant families recorded among nineteen (19) important plant families with high species diversity of more than 50 species in Nigeria.

Furthermore, the genera Ficus L and Dioscorea L have the most diverse number of species with 3 each. Sixty-eight genera or 94.4% of the total enumerated vascular plant species were represented by a single species while 4 genera (5.6%) were represented by 2 or 3 species each. Out of the 39 vascular plant families identified and documented, 26 or 66.7% of the entire flora have only one species occurrence within the habitat. This shows the dominance of families with fewer taxa which make up the flora of the understorey vegetation. Generally, congeneric species (sister species) having similar characteristics and ecological requirements, as explained by Ayodele and Yang (2012) are allopatric in most cases but rarely live together (sympatric). This may account for

the high number of genera and families with one species recorded under the homogenous macro-habitat condition of the pine plantation. The species, *Pityrogramma calomelanos* (L) Link (family: Hemionitidaceae) was the only member of the Ferns and Fern allies (Pteridophytes) recorded. This fern genus is considered to be of American origin but is now virtually pan-tropical in its distribution, occurring sometimes in plantations in West Africa and Nigeria (Wardlaw 1962). However, recent studies indicated that this naturalized plant species (Silver fern) has the potential for multi-functional heavy metal phytoremediation potentials (Young *et al.*, 2010; Mah *et al.*, 2019). Our study recorded no collection of graminoids and sedges under the 36 years old pine plantation.

The life form of plant species recorded from the study showed the dominance of tree species with 32 or 41% of the flora (Fig 3). It was closely followed by shrub with 20 species (25.6%), climbers (19 or 24.4%), herbs with 6 or 7.5% and fern with one (1.28%). The diversity of tree

Table 3: Number of vascular plant species per family in *P. Carribaea* plantation

SN	Family	Genus/ Genera per Family	Species per Family	Percentage Genera	Percentage Species
1	Hemionitidaceae	1	1	1.39	1.28
2	Gnetiaceae	1	1	1.39	1.28
3	Fabaceae	9	11	12.5	14.0
4	Menispermaceae	3	3	4.17	3.85
5	Vitaceae	1	1	1.39	1.28
6	Icacinaceae	2	2	2.78	2.56
7	Connaraceae	3	3	4.17	3.85
8	Sterculiaceae	2	2	2.78	2.56
9	Aristolochiaceae	1	1	1.39	1.28
10	Moraceae	4	6	5.56	7.69
11	Euphorbiaceae	4	4	5.56	5.13
12	Apocynaceae	6	6	8.33	7.69
13	Passifloraceae	1	1	1.39	1.28
14	Sapindaceae	3	3	4.17	3.85
15	Bombacaceae	1	1	1.39	1.28
16	Lecythidaceae	1	1	1.39	1.28
17	Burseraceae	1	1	1.39	1.28
18	Hippocrateaceae	1	1	1.39	1.28
19	Rubiaceae	5	5	6.94	6.41
20	Polygalaceae	1	1	1.39	1.28
21	Longaniaceae	1	1	1.39	1.28
2	Acanthaceae	2	2	2.78	2.56
23	Pandaceae	1	1	1.39	1.28
24	Bignonaceae	2	2	2.78	2.56
25	Combretaceae	1	1	1.39	1.28

26	Cucurbitaceae	1	1	1.39	1.28
27	Araceae	1	1	1.39	1.28
28	Dioscoreaceae	1	3	1.39	3.85
29	Smilacaceae	1	1	1.39	1.28
30	Costaceae	1	1	1.39	1.28
31	Amaryllidaceae	1	1	1.39	1.28
32	Arecaceae	1	1	1.39	1.28
33	Commelinaceae	1	1	1.39	1.28
34	Myristicaceae	1	1	1.39	2.28
35	Capparaceae	1	1	1.39	1.28
36	Annonaceae	1	1	1.39	1.28
37	Dilleniaceae	1	1	1.39	1.28
38	Asclepiadaceae	1	1	1.39	1.28
39	Meliaceae	1	1	1.39	1.28
	Total	**72**	**78**	**100**	**100**

Table 4: Contribution of 5 most diverse families to understorey flora diversity

SN	Family	Genera	Species	% Genera	% Species
1	Fabaceae	9	11	12.5	14.10
2	Moraceae	4	6	5.56	7.69
3	Euphobiaceae	4	4	5.56	5.13
4	Apocynaceae	6	6	8.33	7.69
5	Rubiaceae	5	5	6.94	6.41
	Total	**28**	**32**	**38.89**	**41.03**

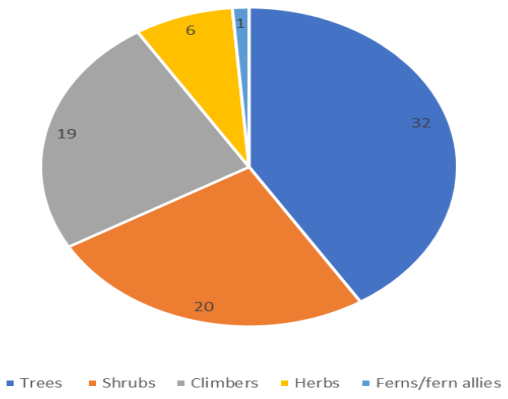

Fig 3: Relative distribution of life forms in the study area

species found in the study area, which may be attributed to plantation age (Onyekwelu and Olabinwonu, 2016) suggested the ability of the understorey vegetation to return to a natural multi-species ecosystem when the overcrop (pines) is removed. Also, apart from economic timber species in the study area, it was found out that some of the plant species encountered and documented are known to be of high ethnobotanical importance to the people of Southeastern Nigeria. These include; *Gnetum africanum* Welw, a dioecious liane growing wild and popular leafy vegetable consumed for its rich nutritional value; *Canarium schwenfunthii* Engl, *Dialum guineense* Willd, an edible fruit tree; *Monodora* tenuifolia Benth (false nutmeg), a local spices; *Sphenocentrum jollyanum* Pierre, *Carpolobia lutea* G.Don, and *Pyrenacantha staudtii* (Engl) Engl, useful in herbal medication.

Conclusion

This study revealed that the 36-year-old pine plantation contains a rich understorey plant species, with most of the recorded vascular plant families represented by a single species. The ability of exotic tree plantations to harbour and conserve native flora if left undisturbed beyond their rotation age is supported by the study. Hence, there is a need for more taxonomic inventory and possibly quantitative assessment of the various Pine Plantations in the country. This will enable the buildup of a floristic data bank and help to guide biodiversity management of understorey plant species.

References

Ariwaodo, J.O and Harry-Asobara, J.L (2015) Preliminary Investigation on flowering and fruiting pattern in a plantation grown *Afzelia africana* Sm stand in Umuahia, Nigeria. *American Journal of Plant sciences* 6:219-227.

Ayodele A.E and Yang Y (2012). Diversity & Distribution of vascular plants in Nigeria, Qingdao publishing house 350pp

Bulut Y and Demir M (2007). The allelopathic effects of scot pine (Pinus sylvestris L) leaf extracts on turfgrass seed germination and seedling growth. *Asian Journal of Chemistry* 19 (14):1169-3177.

Chapin FS, Zavelata ES, Eviner V.T, Naylor R.L, Vitousek P.M (2000). Consequences of changing biotic diversity. *Nature* 405:234-242.

George L.O and F.A Buzzaz (1999). The Fern Understorey as an ecological filter: emergence and establishment of canopy-tree seedlings. *Ecology* 80:833-845.

Harrington R.A. and Ewel J.J. (1997), Invasibity of tree plantations by native and non-indigenous plant species in Hawaii. *Forest ecology and management* 99;153-162.

Heywood V.H, Hawksworth D L, Mirk P.M, Clarke SD (1992). Information needs in biodiversity assessments from genes to ecosystems. Biodiversity information needs and options. Centre for Agriculture and biosciences international, Wallingford, 15-20.

Holmgren P.K Keuken W, E.K. Schofield (1990). Index Herbarium Part 1. The Habaria of the world, 8th ed. Regnum Veg. 12opp, Newyork.

Hutchinson J and Dalziel J.M (1954-1972). Reversed by Keay R. W.J. Flora of West Tropical Africa, 2nd Edition, Vol 1-3. Crown Agent Publishers, London.

Keay R.W.J (1989). Trees of Nigeria, Oxford Science Publication, New York, ISBNO-19-854560-6, 476pp.

Kimura F, Sato M & Kato-ngguchi H (2015). Allelopathy of pine litter; Delivery of

allelopathic substances into the forest floor. *Journal of Plant Biology* 58:61-67.

Mah C.H, Wang Y Lee, S.H, Chen Z, Hong J.W & Tan SN (2019). *Pitygrogramma calomelanos* (L) Link; Silver fern as a copper excluder plant. *Tropical plant research* 6(3): 338-344.

Mbuni YM, Zhou Y, Wang S, Ngumban V.M, *Musili* PM, Mutie FM, Njoroje B, Kirika PM, Mwachala G, Vivian K, Rono P.C, Hu G, Wang Q (2019). An annotated checklist of vascular plants of Cherangani hills, Western Kenya. *Phytokeys* 120:1-90.

Nagaike T, Hayashi A, Abe M; Arai N, (2003). Differences in plant species diversity in Larix kaempferi plantations of different ages in Central Japan. *Forest ecology and management* 183:177-193.

Nektarius P, Economou G, Avgoulas C (2005). Allelopathic effects of Pinus halepesis needles on Turfgrasses and Biosensor plants. *Hortscience* 40(1):246-250

Nzegbule E.C & Ogbonna P.C (2007). Quantity and Quality of Litterfall in Pure Pine and Pine/Gmelina plantations in Umuahia, Abia state. *Global Journal of Agricultural Sciences* 7(1):93-96.

Odiwe A.I, Olowoyo, J.O & Ajiboye .O. (2012). Effects of land-use change in understorey species. Composition and distribution in Tropical Rainforest. *Notulae Scientia Biologicae* 4(1):150-156.

Oladoye, O. (2015). Assessment of floristic Composition of forest undergrowth of International Institute of Tropical Agriculture (IITA) Forest Reserve Ibadan, Nigeria. *Journal of Natural Sciences Research*. 5 (12):58-65.

Olajuyigbe S.O, Olorunnibem V.N and Oluwafor P.E. (2017). Understorey plant species diversity and compositions in a disturbed Old-growth Tectona grandis Linn plantation. *Proceedings of 39th Annual Conference of Forestry Association of Nigeria (FAN)*. PP 190-198.

Onyekwelu J.C. and Fawupe J.A (2008). Conservation and restoration of degraded forest landscapes in rainforest zones of Nigeria through reforestation projects. *Forest and forest product Journal* 1:29-39.

Onyekwelu J.C and Olabinwonu A.A.(2016) Can Forest plantations harbor biodiversity similar to natural forest ecosystem over time? *International Journal of biodiversity science, Ecosystem service & Management* 12 (1&2):108-115.

Rahman M M, Khan S.A; Hossain G M; Rahim M.A (2016). Undergrowth Species Composition of the Exotic and Indigenous Tree Plots in Deciduous Forest Area of Hoteya Forest Range of Tangail District, Bangladesh. American Journal of Plant Biology 1(1):1-12.

Royo A.A. & Carson W.P (2005). On the formation of dense understory layers in forest Worldwide: Consequences and Implications for forest dynamics, biodiversity and succession. *Canadian Journal of Forest Research* 36:1345-1362.

Sukumaran S, Jeeva S, Raji A.D.S.A 2 Kannan D(2008). Floristic diversity, concentration status and economic value of miniature sacred grove in Kanyakumari District, Tamil Nadu, Southern Peninsular India. *Turkish Journal of Botany* 32:185-199.

Tchouto, M.G.P, De Boer, W.F, De Wilde J and Vander Maesen, L.J.G. (2006). Diversity Patterns in the flora of the Compoma a rainforest, Cameroonido tree species tell it all? *Biodiversity conservation* 15;1353-1374.

Wardlaw, C.W (1962). A note on Pityrogramma calomelanos (L)Link, a Fern nuisance in Cameroon Plantations. Journal Ecology 50:129-139.

Wilt, F.M, Miller G.G & Everett R.L (1993a). Measurement of monoterpenes hydrocarbon levels in vapour phase surrounding single-leaf. Pinyon (Pinus monophylla Torr & Fern. (Pinaceae) understorey litter. *Journal of Chemical Ecology* 19 (7): 1417-1428.

Wilt F.M, G.C Miller, R.L Everett & M. Hackett (1993b). monoterpene concentration in fresh, senesced, and decaying foliage of single-leaf pinyon (Pinus monophylla Torr & Fern: Pinaceae) from the western Great Basin. *Journal of Chemical Ecology* 19(2): 185-194.

Yong JWH, Tan SN, Ng YF, Law K.K.K, Peh SF, Chua J.C & LIM ABB (2010). Arsenic hyperaccumulation by *Pteris vittata* and *Pityrogramma calomelanos*, a comparative study of uptake efficiency in arsenic treat soils & waters. *Water science & technology* 61 (12):3041-3049.

Zhang J, Young D.H Oliver, W.W & Fiddler G.O(2016). Effect of overstorey trees on understorey vegetation in California (USA) Ponderosa Pine Plantations. *Forestry* (89):91-99.